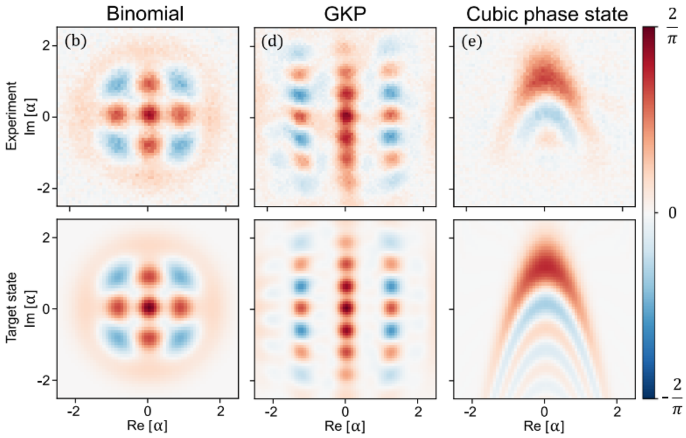
Connectivity in Continuous Variable Quantum Computing
MSc thesis project

202Q-lab, Quantum Technology Laboratory

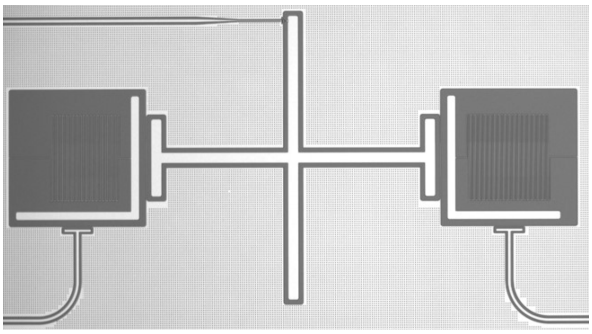
The 202Q-lab is looking for a MSc student who is interested in superconducting quantum circuits.

Background – Continuous-variable (CV) quantum computing aims to utilize bosonic modes for quantum information processing. We have experimentally achieved state-of-the-art manipulation of a single CV-cavity mode [1,2]. However, quantum computing relies on quantum entanglement between several modes. Hence, the cavity modes need coupling elements which mediate the interaction [3]. A key question for scalable quantum computing platforms is how to achieve sufficient connectivity via efficient high-fidelity coupling elements.



State-of-the art quantum Wigner tomography of the quantum state in a single bosonic mode. [2]

The challenge – A huge challenge is to achieve large ON-OFF ratios of the interaction and to avoid spurious side-effects (such as unwanted nonlinearities in the harmonic modes), which are often introduced when subsystems are coupled. This challenge becomes especially difficult when high connectivity between multiple CV subsystems is required, due to frequency crowding and that side-effect mitigation strategies becomes more difficult.



Optical micrograph of a cross-shaped, flux-tuneable coupling element between two lumped-element microwave resonators. (Design by S. Scharmer, unpublished)

The project – The main task of the project is to design and characterize the coupling element between two CV cavities. The candidate will design and simulate the coupled quantum circuits using electromagnetic finite-element- method simulation software. The designed chips will be fabricated by the other members of the group and the candidate will then perform measurements of the devices at mK temperatures inside a cryostat. The device performance will be validated through state-of-the art quantum tomography to demonstrate high-fidelity-quantum entanglement between CV modes.

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] Kudra *et al.*, *High Quality Three-Dimensional Aluminum Microwave Cavities*, Applied Physics Letters **117**, 070601 (2020).
[2] Kudra *et al., Robust preparation of Wigner-negative states with optimized SNAP-displacement sequences,* PRX Quantum **3**, 030301, (2022)
[3] Gao *et al.*, *Entanglement of Bosonic Modes through an Engineered Exchange Interaction*, Nature **566**, 509 (2019).