Optimizing two-qubit gates on a superconducting quantum computer

A fridge for a quantum computing chip; two qubits (red) on the chip, connected through a tunable coupler (green).

Background
Large countries (USA, China, Germany, …) and companies (IBM, Google, …) are racing to build quantum computers on a scale where they can outperform classical supercomputers for certain tasks. In Sweden, Chalmers is leading the 1-billion-SEK, 12-year Wallenberg Centre for Quantum Technology (WACQT), where the core project is to build a superconducting quantum computer with 100 quantum bits (qubits). The quantum computer is built at Chalmers in close collaboration between theory and experiment. This effort involves, e.g., optimizing the lifetime of, and interaction between, single qubits, as well as calibrating parameters for large-scale devices.

Problem description
The goal of the project is to model and optimize a two-qubit gate, i.e., a logical operation involving two qubits. At Chalmers, such gates are implemented using a rapid modulation of a tunable coupler connecting the two qubits. Successful optimization of the gate requires an accurate model of the device, reflecting an understanding of the important parameters in the problem. It also requires an efficient and fast method for searching the parameter space. Developing these things in the project will lay the foundation for scaling up the quantum computer to many more qubits in the future.

Workflow
The project begins with a theoretical study of the superconducting qubits and the two-qubit gate design. You will then implement, using the Python package QuTiP, a numerical model of the gate with experimental parameters as input and run simulations to optimize the gate fidelity.

Team size
3-6 students.

Student background
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Supervisors
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Literature
www.wacqt.se
McKay et al., Physical Review Applied 6, 064007 (2016)