Optimal Control of Sweden's first quantum computer

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

Background
Many universities and companies worldwide, e.g., IBM, Google, and Rigetti, are engaged in the development of quantum computers that can solve problems far beyond the reach of the best conventional supercomputers. In Sweden, we have the Wallenberg Centre for Quantum Technology (WACQT), a 12-year, 1-billion-SEK research programme directed by Chalmers. The main aim of WACQT is to build a 100-qubit superconducting quantum computer at Chalmers. Here, our theory team works in close collaboration with the experimental team on modelling and optimal control of this superconducting quantum computer.

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 quantum system can be formulated as a relatively well-behaved optimal control problem of a bilinear system. You will then apply, using the Julia programming Language, single-shooting optimal control to design two-qubit gates with experimental parameters as input to explore choices for control-signal parameterizations.

Literature

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