Bachelor's Project

Qu tech Qantum Technology Group | RWTH AACHEN UNIVERSITY

Implementation of Filter Function Derivatives for Control Optimization

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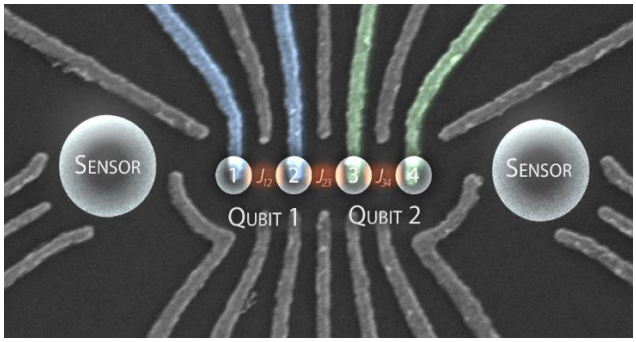

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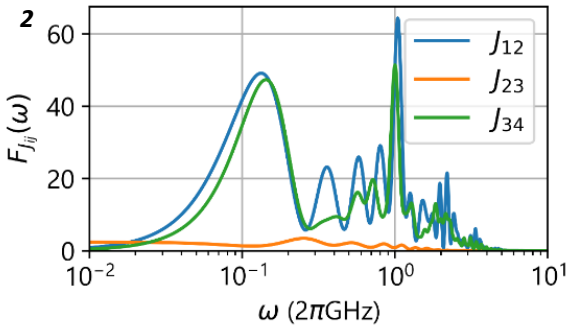

Fig. 1 *STM image of a sample from an experiment currently performed by our group. Four electrons are confined in quantum dots to implement two quantum bits. By applying high-frequency electrical pulses ϵ to the metal gates, the quantum mechanical state of the electrons can be manipulated.*

Fig. 2 *Graph of a filter function describing the susceptibility of a quantum operation to noise as function of the noise frequency. The convolution of the filter function with the actual noise spectrum of the environment gives a measure for the inaccuracy of the corresponding operation.*

Background

Electrons confined in quantum dots are a promising technology for the construction of a universal quantum computer. Specific manipulations of electron states, which can be used for storage and manipulation of data, are called quantum gates. These need to be realised with high precision.

Their performance is currently limited by the detrimental effects of noise caused by the control electronics and the environment. In order to enhance the robustness of quantum gates, the control pulses can be optimized for the least susceptibility to noise effects.

The filter function formalism is a mathematical method describing the interaction of a quantum mechanical system with sources of correlated noise. This method can be faster than explicitly simulating the noise. To use this formalism for optimization algorithms, the efficient calculation of derivatives will be required.

Your Task

Your task will be to extend an existing software package (https://github.com/qutech/filter_functions) by implementing the numerically efficient computation of analytic gradients for the quantum gate accuracy as calculated in the filter function formalism. Subsequently the performance is to be compared with existing methods and used for the optimization of pulses required for current experiments. For this purpose, an optimal control package designed for pulse optimization will be at your disposal. The software is completely written in python and well documented.

This project will allow you to extend your knowledge of these topics, among other things:

- Theory of electron spin qubits and quantum computation
- Quantum mechanics and filter function formalism
- Numerical modelling and programming in python

Furthermore, you will participate in group seminars and Journal Clubs to discuss cutting edge developments in this area of research.

References

https://arxiv.org/abs/1211.1163

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