Master's Project

Simulation of an Integrated Conveyor Architecture

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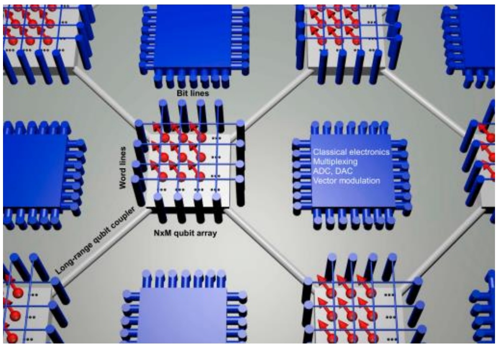

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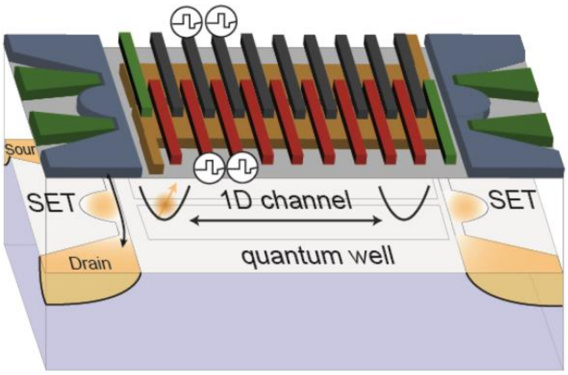

Fig. 1 *Sparse qubit array with local electronics. Long-distance qubit coupling opens up space for local electronics that can control a small dense qubit array. (Vandersypen, npj Quantum Information (2017))*
Fig. 2 *Quantum Bus in Silicon (Si-QuBus). Module for the coherent transport of single electrons across a 1 µm to 10 µm distance while conserving the spin. Control of the potential landscape by an array of metallic top gates. Thereby using the same technology as semiconductor spin qubits. (Schreiber, Poster Quantera)*

Background

Recent technology progress pushed the error rates in semiconductor spin qubits to levels which support useful algorithms. Now the attention shifts from experimental prototypes of single modules to integrated architectures which are designed to enable the simultaneous control of a large number of qubits.
The theoretical investigation of such an architecture requires the combination of the separately studied initialization, manipulation and readout of qubits with the transfer of quantum states over large distances. In doing so the restrictions of each part must be taken into account as well as challenges arising from scaling such as the wiring, cooling power and crosstalk of classical control electronics.
To solve the transfer problem, our group works on the development of a so called conveyor which transfers electrons over large distances. The conservation of the electrons spin state during the transfer is yet to be demonstrated.

Your Task

Combine previous studies conducted by the group to an investigation of an integrated conveyor architecture for a universal quantum computer. Analyse the feasibility and potential regarding system sizes, error rates and computational frequencies. This comprises simulation of missing parts and finding a common regime, in which all required operations are possible. Then design suitable micro magnets which set the parameter regime could be part of the study.
As required, you will perform analytic calculations or numeric simulations. For this purpose, an optimal control package designed for simulation and pulse optimization will be at your disposal (https://git-ce.rwth-aachen.de/qutech/qopt name might change).

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

- Theory of electron spin qubits, quantum computation and open quantum systems
- 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/1612.05936

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