Master's Project

Experimental High-Fidelity Two-Qubit Gates for Spin Qubits

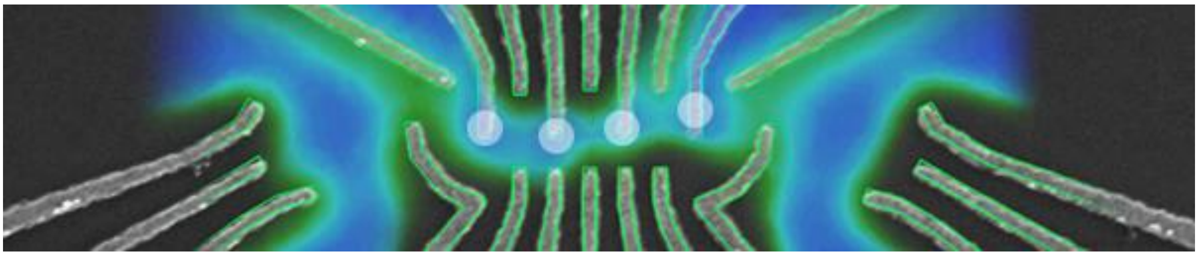

Fig. 1 *Top view of a GaAs sample used in our group, which confines four electrons in two double quantum dots. By applying high-frequency electrical voltage pulses to the grey metal gates, the quantum mechanical state of the left and right qubit can be manipulated individually with very high accuracy. The electron density obtained from simulations in shown in blue.*

Background

A quantum system consisting of 2 electrons can be used to realize a quantum bit (qubit), the smallest unit of a revolutionary new computer concept. The two electrons are confined in a double quantum dot where metal gates allow the manipulation of the qubit's quantum state by applying high-frequency electrical pulses. Fig. 1 shows the experimental realization of two qubits used at our group.

A specific manipulation of the qubit state which can be used for computation is called a quantum gate. In order to execute quantum algorithms successfully, an accurate implementation of these quantum gates is necessary. Gates on single qubits have been demonstrated with high accuracy in this system. However, to perform quantum algorithms manipulations of the joint state of two qubits are also needed.

Your Task

You will work on the experimental demonstration and characterization of a two-qubit gate mediated by the exchange interaction. Using a sophisticated low-temperature (15 mK) measurement setup, you will control two qubits with advanced high-frequency control and readout electronics. In order to obtain accurate two-qubit gates, a precise tuning and understanding of various quantum dot and qubit parameters is necessary, including controlled polarization of GaAs nuclear spins. Furthermore, precise measurement routines need to be developed to characterize the accuracy of the two-qubit gate, once it has been successfully implemented.

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

- Operation of a low-temperature (15 mK) measurement setup
- Manipulation of qubits using sophisticated high-frequency control and readout electronics
- Theory of electron spin qubits and quantum computation
- Quantum mechanics
- Numerical modelling and programming in MATLAB

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

References

Wardrop *et al.,* PRB (2014) http://doi.org/10.1103/PhysRevB.90.045418
Nichol *et al.,* Npj Quantum Information (2017) http://doi.org/10.1038/s41534-016-0003-1

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