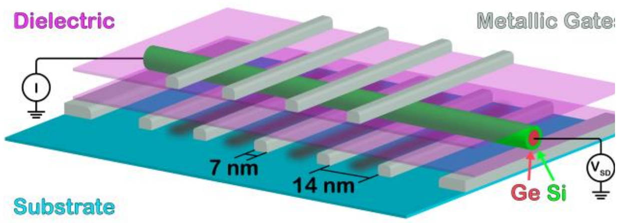
Scientific Area	SA2 Artificial Quantum Systems
Topic title	Hole Spin Qubits in Ge/Si Nanowires
Main host institution	Department of Physics, University of Basel https://physik.unibas.ch
Supervisor/institution	Dominik Zumbühl, Department of Physics, University of Basel https://ZumbuhlLab.unibas.ch
Co-Supervisor/institution	Andreas Fuhrer, IBM Rüschlikon https://www.zurich.ibm.com/
Mentor[1]/institution	Parisa Fallahi, Basel Precision Instruments GmbH https://baspi.ch
Secondment institution	Basel Precision Instruments GmbH https://baspi.ch

Topic description

Semiconductor spins are leading candidates for a scalable qubit. Hole spins, in Ge/Si nanowire quantum dots [1] in particular (Figure), are offering a number of key advantages over other qubits. First, holes have weak hyperfine coupling due to their p-type wave function and are thus much more immune to nuclear spin fluctuations – a major source of decoherence. Second, confined holes are predicted to offer among the strongest spin-orbit interaction (SOI) available, the so called "direct-Rashba" SOI, enabling ultrafast all-electrical spin manipulation. This SOI can be controlled with electric fields, thus allowing to switch to a large SOI for high interaction strengths and fast quantum operations, or to turn off SOI for increased qubit coherence during idling. Furthermore, this SOI results in a g-factor that is locally tunable by electric fields, thus making it possible to selectively address and couple individual spin qubits when many are placed into a superconducting cavity. The rather compact qubit design could pave the way to a multi-qubit system with all-to-all connectivity provided by a single cavity, outperforming other platforms. Here, we will study the fundamental physics at the heart of these qubits.



As the tunable SOI is a central element of the qubit, we will explore it in various ways, incl. avoided crossings, spin-blockade leakage and electric dipole spin resonance (EDSR). With EDSR, we will aim to demonstrate universal 1-qubit control. Further, we will work to implement qubit readout. Finally, we will couple the spin to a cavity photon, and will work towards 2-qubit entanglement and gates.

[1] Froning, Rehmann, Ridderbos, Brauns, Zwanenburg, Li, Bakkers, Zumbühl, and Braakman, Appl. Phys. Lett. 113, 073102 (Aug 2018).

Recommended applicant's profile

We are looking for a highly motivated candidate with an excellent MSc (or equivalent) degree, preferably in physics. Experience in the laboratory on related experiments is desired. You would join a small, international team (3-4 scientists) working together on a leading experiment and would collaborate closely with theoristss as well. Our group is part of the Swiss Nanoscience Institute (SNI) and excellence center in Quantum Science and Technology (QSIT), the European Microkelvin Platform (EMP) and the Basel quantum platform. https://www.quantum.unibas.ch/ https://ZumbuhlLab.unibas.ch

[1] Mentor: The primary role of the mentors will be to identify and facilitate specific training objectives, advise on any problems faced by the ESR, including career matters with an external perspective and provide mediation in the case of disputes.

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