PhD Thesis Project

Modelling silicon and germanium spin qubits

Silicon and Germanium spin qubits have made outstanding progress in the past two years [1, 2]. In these devices, the elementary information is stored as a coherent superposition of the spin states of an electron or hole in a Si/SiO_2 or SiGe heterostructure. These spins can be manipulated electrically owing to spin-orbit coupling, and are entangled through exchange interactions, allowing for a variety of one- and two-qubit gates required for quantum computing and simulation. Grenoble, one of the leading scientific cities in France, is promoting original spin qubit platforms based on Si and Ge, and holds various records in spin lifetimes [3] and spin-photon interactions [4].

At CEA/IRIG, we support the progress of these quantum technologies with state-of-the-art modelling [3, 4]. In particular, we are developing the TB_Sim code, able to describe very realistic qubit structures down to the atomic scale if needed. **The aim of this PhD is to model the quantum dynamics of single and coupled Si/Ge spin qubits in relation with ongoing experiments, using a combination of analytical and numerical (TB_Sim) techniques**. The project will address spin manipulation and entanglement in arrays of spin qubits, the response to noise and disorder (decoherence), and the interactions with photons (circuit quantum electrodynamics). The PhD candidate will have the opportunity to interact with a lively community of experimentalists working on spin qubits at CEA and CNRS. **This PhD is expected to start in September/October 2023 and is fully funded by a grant from the french ANR.**

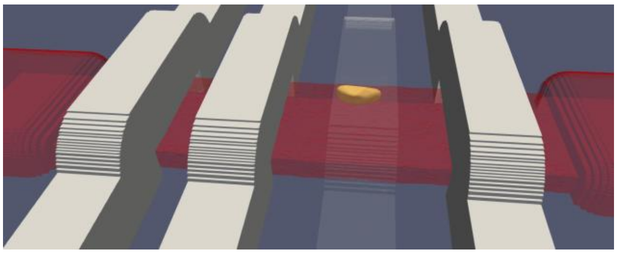

Figure: Model for a silicon spin qubit [3]. The spin of a hole in a silicon channel (red) is controlled by metal gates (white). The yellow shape is an iso-density surface of the hole wave function.

References:

[1] *A four-qubit germanium quantum processor*, N. W. Hendrickx *et al.*, Nature **591**, 580 (2021).
[2] *Universal control of a six-qubit quantum processor in silicon*, S. G. J. Philips *et al.*, Nature **609**, 919 (2022).
[3] *A single hole spin with enhanced coherence in natural silicon*, N. Piot, …, Y.M. Niquet *et al.*, Nature Nano **17**, 1072 (2022).
[4] *Strong coupling between a photon and a hole spin in silicon*, C. X. Yu, …, Y.M. Niquet *et al.*, Nature Nano (2023) [arXiv:2206.14082].

More information about the laboratory:
https://www.cea.fr/drf/irig/english/Pages/Departments/DPhy.aspx
https://scholar.google.fr/citations?user=h02ymwoAAAAJ

More about Grenoble and its surroundings: http://www.isere-tourism.com/

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