Postdoctoral position on the modeling of Si/SiGe spin qubits

January 12, 2024

A post-doctoral position is open at the CEA/LETI (Grenoble, France) on the theory and modeling of Si/SiGe spin quantum bits (qubits). The selected candidate is expected to start spring 2024, for up to two years.

Global context:

Si/SiGe spin qubits have made outstanding progress in the past two years [1]. In these devices, the elementary information is stored as a coherent superposition of the spin states of an electron in a Si/SiGe heterostructure. The spins can be manipulated electrically owing to a synthetic spin-orbit coupling (micro-magnets), and get entangled through exchange interactions, allowing for the implementation of a variety of one- and two-qubit gates required for quantum computing and simulation. Si/SiGe heterostructures provide very clean epitaxial interfaces, and can be made free of nuclear spins that would interfere with the electron spins. They thus hold various records in spin qubit technologies [1].

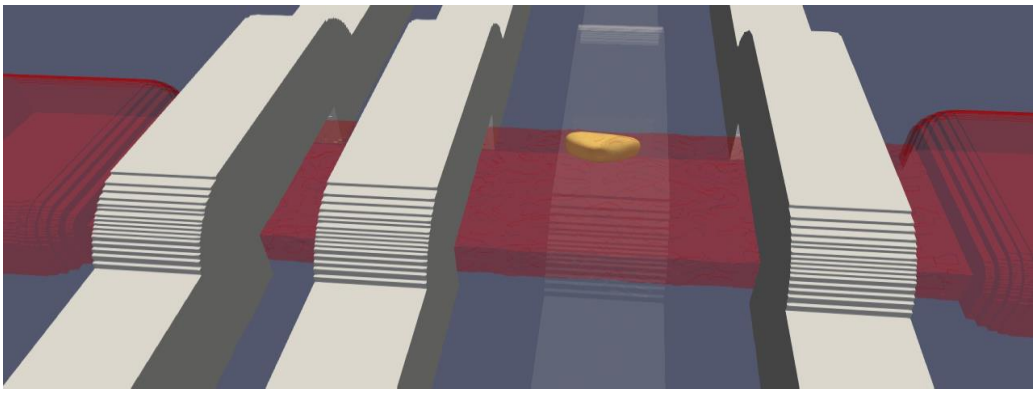

*Fig. 1: TB_Sim model of a silicon device with a silicon channel (in red) controlled by four overlapping gates (in gray). The channel is 100 nm wide, 18 nm thick, and is connected to overgrown reservoirs of charges on both sides. The model includes a realistic disorder (charge traps and roughness, visible at the surface of the channel). An isodensity surface of the ground-state wave function of a hole trapped under the third (semi-transparent) gate, computed with a 6 bands **k.p** model, is plotted in yellow.*

Local context:

It is essential to support the development of advanced quantum technologies with state-of-the-art theory and modeling. For that purpose, CEA/IRIG and CEA/LETI are actively developing the "TB_Sim" code. TB_Sim is able to describe very realistic qubit structures down to the atomic scale if needed using atomistic tight-binding and multi-bands **k.p** models for the electronic structure of materials (see Fig. 1). Using TB_Sim, CEA has recently investigated various aspects of the physics of spin qubits, in tight collaboration with the experimental groups in Grenoble and with the partners of CEA in Europe [2-10].

Objectives of this position:

The aims of this position are to strengthen our understanding of electron spin qubits based on Si/SiGe heterostructures through analytical modeling as well as advanced numerical simulation with TB_Sim. Topics of interests include:

- Structural (strains, …) and electronic properties (spin/valley/orbit couplings, …) in Si/SiGe quantum dots,
- Spin manipulation & readout in electron spin qubits (intrinsic & synthetic spin-orbit coupling fields),
- Exchange interactions in 1D and 2D arrays of qubits and operation of multi-qubit gates,
- Sensitivity to noise (decoherence) and disorder (variability).

Si/SiGe electron spin qubits will, in particular, be benchmarked against Si/SiO_2 quantum dots and Ge/SiGe hole spin qubits in order to get a global picture of the strengths and weaknesses of all semiconductor spin qubit platforms.

The selected candidate will join a lively project bringing together > 50 people with comprehensive expertise covering the design, fabrication, characterization and modeling of spin qubits, as well as related disciplines (cryoelectronics, quantum algorithms and quantum error correction, ...).

How to apply ?

The candidate should send her/his CV to to Biel Martinez i Diaz (biel.martinezidiaz@cea.fr) and Yann-Michel Niquet (yniquet@cea.fr), with a list of publications, a motivation letter with a summary of past accomplishments, and arrange for two recommendation letters. The position is open until filled.

Required qualifications: The candidate must have a PhD in Quantum, Condensed Matter or Solid-State Physics (or related topics), and a taste for numerical modeling.

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

References:

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[7] *Electrical manipulation of semiconductor spin qubits within the g-matrix formalism*, B. Venitucci, L. Bourdet, D. Pouzada and Y.-M. Niquet, Physical Review B **98**, 155319 (2018).

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