Institut de Recherche
Interdisciplinaire de Grenoble

Master/PhD Thesis Project

Quantum thermodynamics in hybrid circuits

Quantum bits are the basic building blocks of future quantum processors. Among candidates as physical units carrying the quantum information (the qubits), hole spins in germanium have recently been spotted as very promising candidates, with the recent demonstration of two, and even four-qubits processors [1-2]. These spin qubits can be initialized, controlled and read, but all these operations are found extremely sensitive to temperature.

In this master project, possibly followed by a PhD thesis, we propose to develop an innovative way to cool down locally germanium nano-structures below the base cryostat temperature, which could have a great impact on future design of Ge-based quantum processors. This will be achieved by placing a germanium nano-structure in contact with a superconductor. Indeed, such superconductor-semiconductor interface provides a very efficient way to cool down the semiconductor, by selective tunnel-out of hot electrons (Fig.1a).

To fulfill this objective, a first approach will be to control the transparency of the superconductor/semiconductor interface [3]. The candidate will also develop strategies to measure temperature of the nano-structure, relying on proximity effect and Coulomb-blockade thermometry. She/he will be involved in the design and fabrication of the Ge/SiGe samples, and characterize them experimentally. This will include measurements in cryogenic environments using dilution refrigerators.

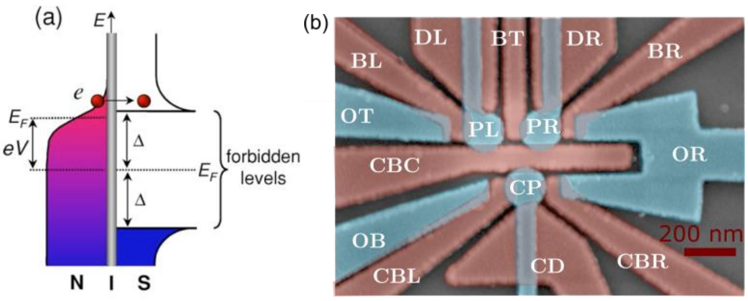

***Fig.1 : (a)** Energy distribution of a semiconductor / insulator / superconductor junction, in the cooling configuration. Hot electrons from the normal part can escape through the barrier to the superconductor. Extracted from [3] **(b)** Complex germanium nano-structure fabricated in the team, including two gate layers (red and blue), which define three different quantum dots.*

References: [1] Hendricks et al., *Nature* (2020) . [2] Hendricks et al., *Nature* (2021)
[3] Giazotto et al., Rev. Mod. Phys (2006)

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