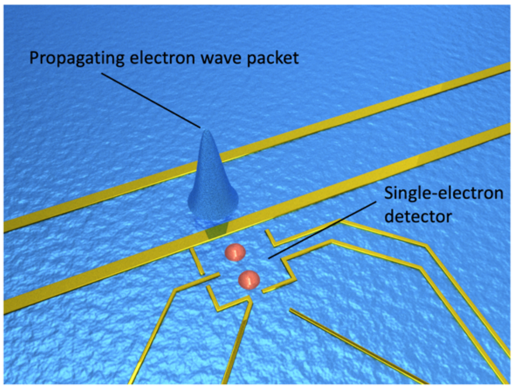
NÉEL INSTITUTE Grenoble

Topic for Master 1 internship – Academic year 2024-2025

Single-electron detector for flying electron wavepackets

General Scope: Coherent manipulation of single electrons in solid-state devices is attractive for quantum information purposes because they have a high potential for scalability. Depending on the system used, the charge or the spin may code binary qubit information. A particular appealing idea is to use a single flying electron itself as the conveyor of quantum information. Such electronic flying qubits allow performing quantum operations on qubits while they are being coherently transferred. Information processing typically takes place in the nodes of the quantum network on locally controlled qubits, but quantum networking would require flying qubits to exchange information from one location to another. It is therefore of prime interest to develop ways of transferring information from one node to the other. The availability of flying qubits would enable the possibility to develop new non-local architectures for quantum computing with possibly cheaper hardware overhead than e.g. surface codes.

Research topic: The remaining brick to be developed for the implementation of a fully-fledged flying electron qubit is a single-shot single-electron detector. The aim of the proposed M1 internship is to participate in the design and characterisation of such a detector based on a double quantum dot to detect a propagating electron wave packet (see Fig. 1). The idea is to use the extreme sensitivity of a quantum system to detect in flight an electron propagating in a ballistic conductor. This will be realized by capacitive coupling of the single flying electron to a spin/charge qubit based on previous experimental work in our group. To enhance the sensitivity, we will develop this detector with a new quantum material, strained Ge heterostructures, which have shown recently the best coherence time for spin qubits.



A single-electron wavepacket is propagating along an electron waveguide in the Femi sea. The charge detector based on a double-quantum-dot qubit detector is placed next to the trajectory and records the passage of the passing electron.

References:

- Edlbauer et al., EPI Quantum Technology 9:21 (2022)
- Thiney et al., Physical Review Research 4, 043116 (2022)
- Roussely et al. Nature Com. 9, 2811 (2018)

Possible collaboration and networking: This project is realized in close collaboration with the quantum transport and spin qubit group at Osaka University.

Required skills:
The candidate should have a strong background in quantum mechanics and solid-state physics. Programming skills in Python would be a plus. We are looking for a motivated candidate. Female students are encouraged to apply.

Starting date: spring 2025

CONTACT:

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