NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2021-2022

Solid-State Electronic Flying Qubits

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 aim of the proposed M2 internship is to participate in the development of an original flying qubit architecture using ultra-short single-electron charge pulses. In order to generate such ultra-short electron wave packets, we will leverage on the progress made on THz photon production and use photon to electron conversion devices to engineer THz electronic charge pulses that can be used in quantum nanoelectronics. Such single electron wave packets are injected into a quantum interferometer to realize the first electronic flying qubit.

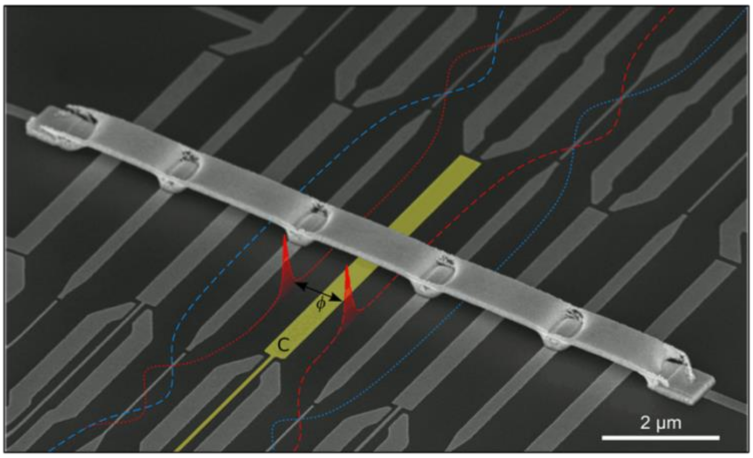

Fig. 1. Scanning electron microscopy image of a multi-qubit flying electron architecture. The image shows four quantum interferometers that can be simultaneously operated owing to a common bridge that connects the islands of each device. The dashed lines schematically indicate the paths of two single-electron wave packets in two neighboring interferometers. The intermediate gate C (highlighted in yellow) allows for controlled Coulomb coupling of the single-electron wave packet and thus in-flight entanglement.

References:

- Roussely et al., Nature Com. **9**, 2811 (2018), Bäuerle et al., Rep. Prog. Phys. **81,** 056503 (2018), Takada et al., Nature Communications **10**, 4557 (2019), Edlbauer et al., Applied Phys. Lett., in print.

Possible collaboration and networking: This project is realized in close collaboration with the nanoelectronics group in Saclay (C. Glattli), the THz laboratory of the Université de Savoie Mont-Blanc (J.F. Roux), the theory group of CEA Grenoble (X. Waintal) as well as the Quantum Metrology group (AIST), Tsukuba, Japan (S. Takada) & the Quantum Device group, RIKEN, Japan (M. Yamamoto)

Possible extension as a PhD: we are looking for a candidate who is motivated to pursue the M2 internship towards a PhD; (PhD fellowship is available)

Required skills:
The candidate should have a good background in quantum mechanics and solid-state physics.

Starting date: preferentially spring 2022 (negotiable)

Contact:

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