NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2022-2023

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. Such an electron flying qubit can be realized through an electronic Mach-Zehnder interferometer as shown in Fig.1. Based on our recent experiments with such an electron flying qubit, we aim at coupling two electron flying qubits to realise quantum entanglement of 2 injected electron wave packets through Coulomb interaction (C) as highlighted in the figure.

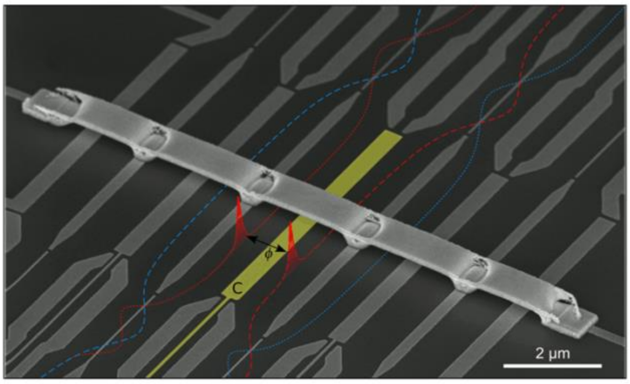

Fig. 1. SEM image of a multi-qubit flying electron architecture. The image shows four quantum interferometers that can be simultaneously operated owing to a common bridge that connects the islands of each device. The dashed lines schematically indicate the paths of two single-electron wave packets in 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:

- Bäuerle et al., Rep. Prog. Phys. 81, 056503 (2018) ; arxiv.org/abs/1801.07497, Edlbauer et al., EPI Quantum Technology 9: 21 (2022); in COLLECTION ON "QUANTUM INDUSTRY", REVIEW ARTICLE; https://doi.org/10.1140/epjqt/s40507-022-00139-w

Possible collaboration and networking: This project is part of the priority projects of the French National Strategy on Quantum Technologies. It is realized in close collaboration with the nanoelectronics group in Saclay (C. Glattli & P. Roulleau), the THz group of IMEP-LaHC laboratory at Univ. 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 can be obtained)

Required skills:
The candidate should have a good background in quantum mechanics and solid-state physics. Programming skills in Python would be a plus.

Starting date: open (preferentially beginning 2023)

Contact:

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