PhD thesis project at NEEL INSTITUTE Grenoble

Entanglement with propagating 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 aim of the proposed PhD project is to develop 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. Based on our recent experiments with such an electron flying qubit (arXiv:2408.13025), we aim at coupling two electron flying qubits to realise quantum entanglement of two injected electron wavepackets through Coulomb interaction as highlighted in the figure on the right.

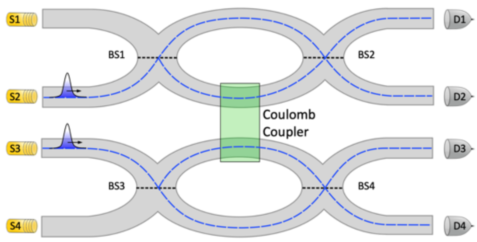

Fig. 1: Two Coulomb-coupled flying qubits in the form of two electronic Mach-Zehnder interferometers. By synchronously injecting two electron wavepackets from sources S2 and S3, the two flying qubits can become entangled via Coulomb interaction. Entanglement can be measured using the four detectors, either through noise correlation measurements or single-shot readout.

References:

- S. Ouacel et al., arXiv:2408.13025 ; 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 CEA Saclay (P. Roulleau) the theory group of CEA Grenoble (X. Waintal) as well as an French-Japanese International Research Project with AIST, RIKEN and the University of Osaka.

Required skills:
Master 2 or engineering degree. We are looking for an excellent and highly motivated candidate for an experimental PhD thesis. The candidate should have a strong background in quantum mechanics and solid-state physics. Programming skills in Python are highly appreciated.

PhD funding: QuantAlps PhD program with deadline March 14th, 2025 ; See Call for application.
Foreseen start of the grant: September - November 2025.
Amount : gross salary prior to employee tax deduction about 2300 €.
Duration : 36 months

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