NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2025-2026

Control and Braiding of Anyons in Quantum Boxes

General Scope
Anyons are quasiparticles that emerge in low-dimensional (d < 3) electronic systems. Their interest lies in their unconventional quantum statistics, neither bosonic nor fermionic, which allow manipulation of the system's ground state by exchanging particle positions. This process, called braiding, is a route toward topological qubits with exceptionally low error rates [1]. Moreover, the exploration of a new quantum statistics beyond the fermion–boson dichotomy is of considerable fundamental interest.

Research topic
This project will explore anyons in bilayer graphene, a platform where robust fractional quantum Hall states have recently been demonstrated [2]. The objective is to confine a single anyon in an electrostatic potential well, in order to investigate the capability of such "anyon box" structure for topological quantum information. The candidate will gain hands-on experience in advanced nanofabrication, integrating aluminum single-electron transistors (SETs) with anyon boxes, and perform state-of-the-art cryogenic quantum transport measurements. This project offers a unique opportunity to contribute to cutting-edge research at the interface of condensed matter physics and quantum technologies.

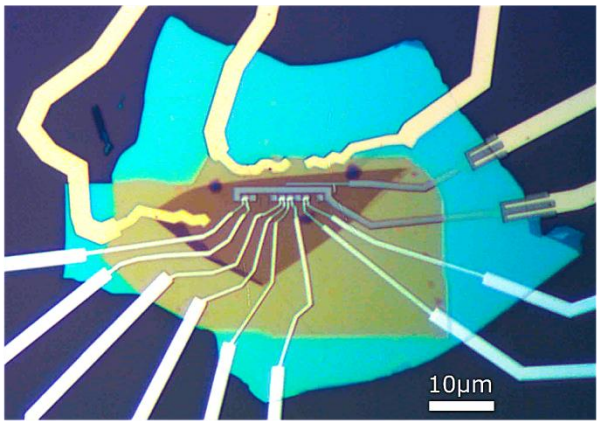

Figure : Optical image of the device architecture showing the SETs (white leads) on top of a bilayer graphene heterostructure. The SETs enable to extract thermodynamic variable such as the anyon chemical potential and entropy.

Research environment
The intern/PhD student will join the young and dynamic QuNES team, composed of several PhD students and postdocs, and will contribute to the group's research activities alongside Alexandre Assouline, Benjamin Sacépé, and Hermann Sellier. The QuNES team conducts top-level research that is regularly published in high-profile international journals.

[1] Non-Abelian anyons and topological quantum computation
C. Nayak et al. Rev. Mod. Phys. **80**, 1083 (2008)
[2] Energy gap of the even-denominator fractional quantum Hall state in bilayer graphene
A. Assouline et al. Phys. Rev. Lett. **132**, 046603 (2024)

Possible extension as a PhD: PhD grant available through ERC project: **ANYONBOX**
Required skills: Motivation in pursuing a PhD in quantum condensed matter physics
Starting date: Flexible
Contact: Alexandre Assouline - alexandre.assouline@neel.cnrs.fr