NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2021-2022

Spectroscopy of superconducting quantum Hall edge channels

General Scope : Since its first observation in 2005, quantum Hall effect (QHE) in graphene has been at the heart of intense research efforts. This effect occurs when a 2-dimensional electron gas is subjected to a perpendicular magnetic field and is characterized by a current flowing through topological edge channels. In recent years, our group contributed to the continuous improvements in graphene-based heterostructures quality allowing the observation of many quantum coherent effects such as Fabry-Pérot interferometry [1] and helical transport [2]. Supercurrent in the quantum Hall regime [3] has also been demonstrated. Our project aims to perform tunneling experiments to access to the edge channels local density of states. This approach will require the implementation of aluminum-based tunneling electrodes on the edges of state-of-the-art graphene van der Waals heterostructures.

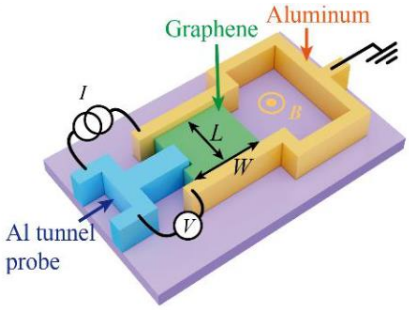

Figure 1. Schematic of an Al-based tunneling probe used to study graphene-based Josephson junction. Figure taken from [4].

[1] C. Déprez et al, *A tunable Fabry-Pérot quantum Hall interferometer in graphene*, Nature Nanotechnology volume 16, pages 555–562 (2021)
[2] L. Veyrat et al, *Helical quantum Hall phase in graphene on SrTiO3,* Science 367, 781 (2020)
[3] F. Amet et al, *Supercurrent in the quantum Hall regime*, Science 352, 966 (2016)
[4] S. Park et al, *Steady Floquet-Andreev States Probed by Tunnelling Spectroscopy*, arXiv:2105.00592

Research topic and facilities available:

In this internship the M2 student will fabricate hBN-encapsulated graphene devices and develop aluminum-based probe to perform tunneling experiments in the quantum Hall edge states. Measurements will require the use of low-noise electronic set-up, high magnetic field and very low temperatures (0.01 K) using dilution fridges. Data analysis and interpretation will also be part of the work. This approach will be used in a long-term PhD project to study the coupling between QHE and superconductivity, a promising path towards the realization of new exotic quasiparticles.

Collaboration and networking : Hermann Sellier, QuNES team, Institut Néel.

Possible extension as a PhD : Yes, funded by an ERC Consolidator grant.

Required skills:
Our group is looking for a highly motivated and inquisitive student, with a significant background in quantum and/or condensed matter physics and a strong interest for experimental physics.

Starting date : Spring 2022 or earlier.

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