INTERNSHIP PROPOSAL

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Thesis possibility after internship: YES
Funding: NO (not sure at that time) If YES, which type of funding:

Quantum transport of charge and heat in non-abelian quantum hall states of graphene

Even-denominator states of the fractional quantum Hall effect (e.g. ν=5/2) are expected to host excitations that have non-abelian anyonic statistics, making them promising candidates for the realization of topological quantum computing [1]. While the demonstration of these statistics has long been an extremely challenging task, recent experiments in GaAs semiconductor heterostructures have shown that the edge thermal conductance of the ν=5/2 state is quantized in half-integer values of the thermal conductance quantum [2,3]. This half-integer quantization is known to be a universal signature of non-abelian statistics, including of Majorana fermions [4]. The next obvious interrogation is whether this result is truly universal: does it hold for different materials, and different even-denominator states?

In this project, we propose to address these questions by performing both heat and charge transport measurements in fractional quantum Hall states in bilayer graphene (BLG), which has recently shown to host a large variety of robust even-denominator fractional quantum Hall states [5-8]. This provides an excellent test-bed on which to probe the thermal conductance, as these fractions are expected to be described by different (possibly non-abelian) ground states.
In addition to heat transport, we will perform collision experiments, that have recently allowed demonstrating the existence of abelian anyonic statistics in other states of the fractional quantum Hall effect in GaAs [9,10,11]. These experiments, based on the same experimental techniques as heat transport, will provide a definitive answer on the non-abelian nature of even-denominator states.

This experimental project relies on ultra-low temperature, high magnetic field thermal transport [12,13] and collision [9,10,11] based on high sensitivity electrical measurements. We are looking for highly motivated candidates who are interested in all aspects of the project, both experimental (sample fabrication, low noise measurements, cryogenics) and theoretical. This project will be implemented at LPENS, in collaboration with the Centre de Nanosciences et de Nanotechnologies (C2N, Palaiseau).

[1] Nayak, et al., RMP 80, 1083 (2008)
[2] Banerjee, et al., Nature 559, 205 (2018)
[3] Dutta, et al., Science 377, 1198 (2022)
[4] Kasahara, et al., Nature 559, 227 (2018)
[5] Ki, et al., Nano Letters 14, 2135 (2014)
[6] Li, et al., Science 358, 648 (2017)
[7] Zibrov, et al., Nature 549, 360 (2017)
[8] Huang, et al., PRX 12, 031019 (2022)
[9] Bartolomei, et al., Science 368, 173 (2020)
[10] Ruelle et al., PRX 13, 011031 (2023)
[11] Glidic et al., PRX 13, 011030 (2023)
[12] Le Breton, et al., PRL 129, 116803 (2022)

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: NO