Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: **Matériaux et Phénomènes Quantiques – MPQ**
CNRS identification code: **UMR7162**
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Thesis possibility after internship: YES
Funding: NO

Topology and Chern bands in twisted multilayer graphene

Graphene alone, first isolated in 2014, is a very versatile experimental platform due to its remarkable topological band properties and the fact that it exhibits a very pure two-dimensional structure. It has been recently (2018) experimentally demonstrated [1,2] that twisting two overlaid monolayers of graphene can deeply modify the band structure up to a point where the kinetic energy is essentially quenched at a magic angle, and Coulomb interactions dominate. Following experiments have revealed numerous striking behaviors in such a simple system: (unconventional) superconductivity, correlated insulating phases, integer and fractional topological insulators, strange-metal resistivity (same as in high-Tc superconductors), spontaneous flavor ferromagnetism, nematicity, etc. Twisted bilayer graphene emerges today as an extremely promising route to explore a variety of very interesting quantum phases where interactions and topology play a crucial role.

The aim of this internship is to investigate the formation of topological bands in twisted bilayer graphene and, more broadly, in multilayer graphene structures. We will use a well-established continuum model [3] that describes electron hopping between graphene layers to explore the conditions under which energy bandgaps emerge in the spectrum, leading to the creation of topological bands. These topological features are expected to be directly inherited from those of monolayer graphene, resulting in the emergence of robust one-dimensional edge modes encircling the two-dimensional system. These edge modes carry electric current and are responsible for the generation of quantized Hall resistance, even in the absence of an external magnetic field [4].

[1] Y. Cao et al., Nature 556, 43 (2018)
[2] Y. Cao et al., Nature 595, 526 (2021)
[3] R. Bistritzer, A. MacDonald, PNAS 108, 12233 (2011)
[4] M. Serlin et al., Science 367, 900 (2020)

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: YES