Project 4.1: Tunable topological devices from superlattices (theoretical)

Supervisor: dr Alexander Lau /dr hab. Wojciech Brzezicki

(Group of Physics of Majoranas headed by Timo Hyart)

http://www.magtop.ifpan.edu.pl/resources/people/

Institute: IFPAN

Unit: ON-6.5: International Centre for Interfacing Magnetism and Superconductivity with Topological Matter "MagTop", Group of Physics of Majoranas

WWW: https://www.magtop.ifpan.edu.pl/ (see jobs)

Background:

Topological phases of matter are among the most actively studied topics in modern condensed matter physics. Building a bridge from abstract mathematical concepts to materials with exceptional properties, topological materials have not only pushed forward our fundamental understanding of solids but could also lead to revolutionary applications, for instance, quantum computers and electronic devices with low power consumption. In view of these applications, it is important to design setups that allow to realize topological phases with taylored properties that can be tuned easily. Superlattices are a promising platform for this endeavor due to technological advances in the precise fabrication of nanodevices. Superlattices are created by stacking sheets of 2D materials, such as graphene, by patterning adatoms on their surface, or by twisting the individual layers (moiré superlattices). This naturally endows superlattices with a high degree of tunability. In this project, the student will study superlattices of layered van-der-Waals materials as platforms for tunable topological devices. The interplay of the underlying electronic structures with the ingredients and configuration of the superstructures is envisioned to lead to new phases with highly altered properties.

The student will study this interplay theoretically by modelling the various setups and by performing numerical calculations. The arising phases will be analyzed with a focus on transport phenomena and topological invariants.

Aim:

Model and theory for van-der-Waals superlattices based on moiré patterns and adatoms. Identification and characterization of topological phases. Optimization of tuning parameters with respect to topology and transport properties.

Requirements:

- MSc in Physics with strong background in Theoretical Physics
- basic programming skills

Funding:
Scholarship and project within the Programme International Research Agenda of the Foundation for Polish Science (https://www.fnp.org.pl/en/oferta/irap/). For first year students, the net amount is 3500 PLN.

Contact: alexlau@magtop.ifpan.edu.pl , brzezicki@magtop.ifpan.edu.pl, hyart@magtop.ifpan.edu