INTERNSHIP PROPOSAL

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Thesis possibility after internship: YES
Envisaged funding? Doctoral school or research grant

The birth of ferroelectric topological insulators

In recent years, merging of topology with other physical phenomena such as superconductivity, ferromagnetism or ferroelectricity as attracted tremendous interest. The resulting reduction of symmetry has led to outstanding breakthroughs and the discovery of novel exotic phases of matter, such as the quantum anomalous Hall phase in the presence of magnetic interactions and Majorana fermions at the interface of a quantum anomalous Hall insulator and a superconductor. These are considered to be highly promising roads towards quantum computing because of the robustness of Majorana fermions against decoherence and in addition, numerous other applications have been envisioned.

In the present proposal, we will focus on the intriguing interplay between topology and ferroelectricity. From a fundamental point of view, combining ferroelectricity with topology is predicted to host Weyl fermions. These relativistic fermions can be mimicked by massless electrons that possess a definite chirality, meaning that their spins are parallel or antiparallel to their momenta. They are at the heart of a large number of outstanding properties that are just starting to be addressed, such as dissipationless chiral currents driven by the chiral magnetic effect, efficient spin-charge conversion due to the large anomalous Hall effect or efficient higher harmonic generation due to ultrafast dynamics. Weyl fermions are also promising particles to form qubits based on chirality. Therefore, it is of great interest to establish a platform capable of control and manipulation of Weyl fermions.

The objective of the project is to develop ferroelectric topological insulators as a new class of quantum materials and to employ them for the control and manipulation of chiral Weyl fermions. The three goals of the project will be to

- Design and synthesize novel ferroelectric topological materials,
- Demonstrate the interplay between the ferroelectric distortions and fundamental electronic properties to induce and tailor Weyl Fermions,
- Unravel novel transport and optical phenomena specific to the Weyl phase in order to open up new routes towards Weyl physics applications.

The experimental techniques at LPENS will be magneto-spectroscopy in the THz and MIR domain and quantum magneto-transport under high magnetic field up to 17 teslas, in the temperature range 1.6-200K. The high quality studied heterostructures will be grown by molecular beam epitaxy and characterized using XRD, STM and ARPES by our collaborators at the Johannes Kepler University in Linz (Austria).

Refs: N. P. Armitage, E. J. Mele, A. Vishwanath, Rev Mod Phys. 90, 15001 (2018).
N. P. Ong, S. Liang, Nature Reviews Physics. 3, 394–404 (2021).

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