Laboratory Name: Institut de Physique Théorique (IPhT)

Institution: CEA DRF-INP, CNRS UMR 3681, Université Paris-Saclay

Internship director: Benjamin WIEDER

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Address: Orme des Merisiers bâtiment 774, F-91191, Gif-sur-Yvette Cedex

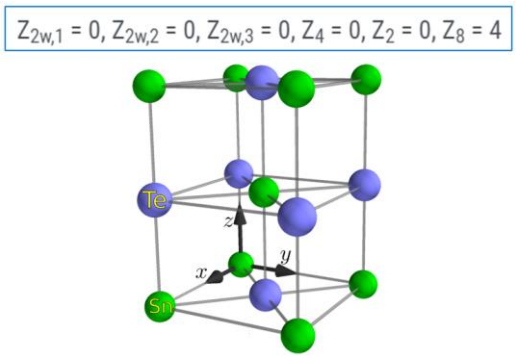
Internship Place: IPhT, Université Paris-Saclay

Possibility of PhD Thesis after internship: YES

Funding already obtained for a PhD: YES

Symmetry, Spin, and Topology in Crystalline Insulators and Superconductors

Over the past 10 years, researchers including members of our team have shown that nearly every stoichiometric 3D solid-state material exhibits topological features in its electronic spectrum. In the simplest models, these features may be linked to well-understood, robust phases of matter such as integer quantum Hall states. However, real semiconductors exhibit more complicated symmetries, boundary terminations, chemical effects, disorder realizations, and electronic correlations than the tight-binding toy models frequently used to study topological states. It remains a significant and open question how to unify the current classification of topological crystalline materials with universal and industry-relevant experimental observables in longer-wavelength response theories, especially in the presence of interactions, disorder, and superconductivity.



The mathematical topological classification of 3D SnTe crystals.

Our team has made rapid, recent advances in this direction by leveraging hidden information in the electronic spin degree of freedom in topological materials, and by introducing and characterizing new variants of symmetry group theory in interacting and spinful materials. Funded by our recently awarded ERC Starting Grant TopoRosetta (https://cordis.europa.eu/project/id/101117835), this internship will provide students an opportunity to perform theoretical and numerical investigations of the interplay of electromagnetic response, long-wavelength topological forms (*e.g.* axion angles), and crystalline symmetry group theory to unravel the classification of and best real-material platforms for topological order and superconductivity. Our team also performs first-principles density-functional theory (DFT) simulations of real materials, and motivated students will have the opportunity to learn these techniques. We further work closely with experimental groups including those at the Laboratoire de physique des Solides, and interested students will have the opportunity to join these discussions.

This position is designed for students with significant previous experience in solid-state and condensed matter physics, a strong background in mathematics and quantum mechanics, and demonstrated experience with computation analysis and coding (especially working with Python). Applicants should be proficient and prepared to conduct research, write papers, and give seminars in English. Preference will be given to applicants that express a strong desire to continue onwards from this internship to a PhD with the Wieder Research Group, which will entail a significant amount of English-language Zoom and in-person meetings with our international collaborators, and attending and presenting at overseas research visits and conferences.