DOCTORATE THESIS

Symmetry-protected topological phases: From Floquet theory to machine learning

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It is by now a well known fact that boundary states in conventional time-independent topological insulators are protected against perturbations that preserve relevant symmetries. In the first part of this thesis, accompanying Papers A - C, we study how this robustness extends to time-periodic (Floquet) topological insulators. Floquet theory allows us to go beyond ordinary time-independent perturbations and study also periodically-driven perturbations of the boundary states. The time-dependence here opens up an extra lever of control and helps to establish the robustness to a much broader class of perturbations. In Paper A, a general idea behind the topological protection of the boundary states against time-periodic perturbations is presented. In Paper B we address the experimental detection of the proposed robustness and suggest that signatures of it can be seen in the measurements of linear conductance. Our idea is explicitly illustrated on a case study: A topologically nontrivial array of dimers weakly attached to external leads. The discussed features are described analytically and confirmed numerically. All computations are performed by employing a convenient methodology developed in Paper C. The idea is to combine Landauer-Büttiker theory with the so-called Floquet-Sambe formalism. It is shown that in this way all formulas for currents and densities essentially replicate well known expressions from time-independent theory.

To find closed mathematical expressions for topological indices is in general a nontrivial task, especially in presence of various symmetries and/or interactions. The second part of the thesis introduces a computational protocol, based on artificial neural networks and a novel topological augmentation procedure, capable of finding topological indices with minimal external supervision. In Paper D the protocol is presented and explicitly exemplified on two simple classes of topological insulators in 1d and 2d. In Paper E we significantly advance the protocol to the classification of a more general type of systems. Our method applies powerful machine-learning algorithms to topological classification, with a potential to be extended to more complicated classes where known analytical methods may become inapplicable.

The thesis is meant to serve as a supplement to the work contained in Papers A-E. Here we provide an extensive introduction to Floquet theory, focused on developing the machinery for describing time-periodic topological insulators. The basic theory of artificial neural nets is also presented.

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