Master Thesis Project

Laboratoire: CINaM

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Modeling topological condensed matter using electronic circuits

Topological phases in condensed matter have become one of the most vibrant branches in contemporary physics [1], recently recognized by the 2016 Nobel prize in Physics. In such topological phases, the ground state wave function is characterized by its so-called Chern number and features protected each states coexisting with insulating bulk states. The creativity of theorists in this field of research has been extraordinary and entirely novel classes of topological systems have been discovered lately, from topological insulators and semimetals to systems displaying non-Hermitian and nonlinear higher-order topology [2-5]. However, the realization of such exotic phases of matter remains extremely challenging in real materials.

A few years ago, it was proposed to circumvent this difficulty by modeling these exotic phases using conventional electrical circuits [3,4]. This approach launched a new research direction, called topolectronics. This completely disruptive approach enables the conception of extremely unusual phases such as our recently proposed second-order non-Hermitian skin effect [5]. In this project, the student will explore the potential of topolectronics to model exotic systems such as Kitaev chain or Haldane model. Our ambition is to extend this methodology to model spin-dependent transport.

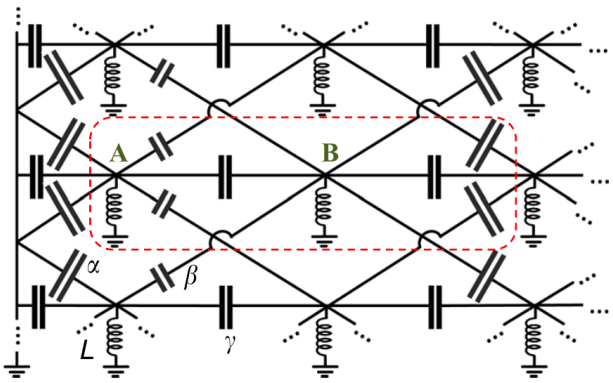

Figure 1 : Topological graphene modeled using conventional circuit components.

[1] Qi and Zhang, Topological insulators and superconductors, Review of Modern Physics 83, 1057 (2011)
[2] Schindler et al., Higher-order topological insulators, 4 eaat0346 (2018)
[3] Lee et al., Topolectrical Circuits, Communication Physics 1, 39 (2018)
[4] Imhof et al., Topolectrical-circuit realization of topological corner modes, Nature Physics 14, 925 (2018)
[5] Ce et al, Experimental identification of the second-order non-Hermitian skin effect with physics-graph-informed machine learning, arXiv:2203.00484 (accepted in Advanced Science 2022)