Higher-order topological insulators (Theory)

Contact: Julia MEYER DRF//INAC/PHELIQS/GT julia.meyer@cea.fr 04 38 78 31 46

PhD may follow: Yes

Summary :

Topological insulators are materials that are insulating in the bulk, but host topologically-protected conducting surface states. Much more recently the possibility of higher-order topological insulators has been predicted, where the conducting states live in two dimensions less than the bulk. Experimental evidence for such "hinge" modes has recently been found in Bismuth. Here, we want to explore the differences between the onedimensional edge states of a twodimensional topological insulator and the hinge modes of a threedimensional higher-order topological insulator.

Full description :

Topological insulators are materials that are insulating in the bulk, but host topologically-protected conducting surface states. As such the twodimensional quantum (spin) Hall insulator possesses robust onedimensional edge channels. Much more recently the possibility of higher-order topological insulators has been predicted [1], where the conducting states live in two dimensions less than the bulk. For example, a threedimensional system may have an insulating bulk and surfaces, but topologically-protected onedimensional Â« hinge Â» modes (see picture). Experimental evidence for such hinge modes has recently been found in Bismuth [2]. Here, we want to explore the differences between the onedimensional edge states of a twodimensional topological insulator and the hinge modes of a threedimensional higher-order topological insulator [3]. In particular, we will study their coupling to superconductors in Josephson junctions. Furthermore, we will consider the effect of disorder and a possible coupling to residual bulk/surface states.

[1] W.A. Benalcazar et al., Science 357, 61 (2017).
[2] F. Schindler et al., Nat. Phys. 14, 918 (2018).
[3] R. Queiroz and A. Stern, preprint arXiv:1807.04141.

Requested skills :

The theory project will be performed mainly by using the analytical tools of condensed matter field theory. It may also involve numerical aspects. Interested candidates should have a good basis in quantum mechanics, statistical physics, and solid state physics.