The Alabama Collaborative for Materials Exploration (ACME)

Research Seminar Series

Dr. Yafei Ren
Department of Physics & Astronomy
University of Washington

Tuesday, November 30th, 2021
10:00 AM CST
Register for Zoom here

Variants of quantum Hall effect: 3D quantum Hall effect, orbital Chern insulator, and higher-order topological insulators

Topological physics has become a focal point of condensed matter physics since the discovery of the quantum Hall effect in a two-dimensional electron gas under a magnetic field. We recently discovered strong evidence for the three-dimensional quantum Hall effect in ZrTe5 in collaboration with an experimental group [1]. Under a 2T B field, the experimentalists observed a plateau of Hall conductance and a nearly disappearing longitudinal resistance in a bulk sample with a thickness of 0.1 cm. This behavior is attributed to the charge density wave generated by interaction in the lowest Landau band. Another variant of the quantum Hall effect without a B field is called the Chern insulator, which was first proposed by Haldane in a model with alternative magnetic flux. We demonstrate that in a Kagome lattice, an alternative magnetic flux can form spontaneously driven by interaction [2]. The Chern number is proportional to the orbital magnetization, whereas spin has no effect. As a result, we refer to this as an orbital Chern insulator. The Chern insulator associated with orbital magnetization is also found in materials with in-plane ferromagnetic order in which the lattice should violate mirror z symmetry [3]. By combining the Haldane model and its time-reversal copy, a Z2 topological insulator is formed proposed by Kane and Mele. When an in-plane Zeeman field is applied to this model, time-reversal symmetry is broken but a mirror symmetry is preserved. We find that the latter symmetry can protect edge states along edges respect this symmetry. Corner states appear between edges break this symmetry [4]. Such behaviors are closely related to the topological crystalline insulator and higher-order topological insulator.

[1] Nature 569, 537-541 (2019)
[2] PRL 126, 117602 (2021); PRB 98, 205146 (2018)
[3] PRB 94, 085411 (2016); PRB 96, 241103 (2017)
[4] PRL 124, 166804 (2020)

Biography: Yafei Ren, Ph.D., is a postdoctoral researcher at the University of Washington. He earned both his B.S. and Ph.D. degrees from the University of Science and Technology of China and worked as a postdoc at the University of Texas at Austin. His research focuses on the topological phases induced by spin-orbit coupling and interaction, including Chern insulator, higher-order topological insulator, and three-dimensional quantum Hall effect. He has recently turned his attention to the geometrical phase effect on the low-frequency elementary excitations, such as phonons. He has about 30 publications in PRL, PRB, Nature, Nat. Nano., and a review article on Reports on Progress in Physics.

For more information see our website at https://acme.ua.edu

Receive links to our future ACME Materials Seminar Series: https://acme.ua.edu/register-for-seminars.html