*Available online at* www.scholarsresearchlibrary.com

Extended Abstract

**Archives of Physics Research, 2021, 13 (6)**
(https://www.scholarsresearchlibrary.com/journals/archives-of-physics-research/)

**ISSN 0976-0970**
**CODEN (USA): APRRC7**

# Topological quantum states visualized by ARPES: From topological kondo insulator to Weyl semimetal

**Nan Xu**

*Paul Scherrer Institute, Switzerland*

*E-mail: nan.xu@psi.ch*

Recently, topological classifications of quantum phases have been extended from non-interacting insulators to strongly correlated insulators, and further to semimetals. In this talk, I will introduce our recent results on direct visualizations of several topological quantum states with angle-resolved photoemission spectroscopy (ARPES). The direct observation the metallic surface states on strongly correlated Kondo insulator SmB6 and its helical spin texture of as compelling evidences for the predicted topological kondo insulator. Direct observation of 3D Weyl cones in the bulk states of topological semimetal TaAs, as experimental evidence of Weyl semimetal states. Discovery simple Weyl semimetal TaP, where only single type of Weyl fermions contributing the exotic transport properties. Observation of Fermi arc states in MoTe2 as evidence of type-II Weyl semimetal state. Topological insulators and topological semimetals are both new classes of quantum materials, which are characterized by surface states induced by the topology of the bulk band structure. Topological Dirac or Weyl semimetals show linear dispersion around nodes, termed the Dirac or Weyl points, as the three-dimensional analog of graphene. We review the basic concepts and compare these topological states of matter from the materials perspective with a special focus on Weyl semimetals. The TaAs family is the ideal materials class to introduce the signatures of Weyl points in a pedagogical way, from Fermi arcs to the chiral magnetotransport properties, followed by hunting for the type-II Weyl semimetals in WTe2, MoTe2, and related compounds. Many materials are members of big families, and topological properties can be tuned. As one example, we introduce the multifunctional topological materials, Heusler compounds, in which both topological insulators and magnetic Weyl semimetals can be found. Instead of a comprehensive review, this article is expected to serve as a helpful introduction and summary by taking a snapshot of the quickly expanding field. Hermann Weyl demonstrated the existence of a massless fermion in the Dirac equation which was later called the Weyl fermion.

In the standard model, all fermions are Dirac fermions, except possibly neutrinos that present chirality. However, neutrinos were later found to be massive and excluded from Weyl fermions. Weyl fermions have remained undiscovered until very recently in condensed matter systems. In solid-state band structures, Weyl fermions exist as low-energy excitations of the WSM, in which bands disperse linearly in three-dimensional (3D) momentum space through a node termed a Weyl point. The band structure of a WSM originates from the band inversion in proximity to a TI. The Berry curvature is a quantity that can characterize the topological entanglement between conduction and valence bands, which is equivalent to a magnetic field in the momentum space. The Berry curvature becomes singular at Weyl points that act as monopoles in the momentum space with a fixed chirality: Such a Weyl point can be a source (+ chirality) or a sink (− chirality) of the Berry curvature. These Weyl points always appear in pairs otherwise, the Berry flux becomes divergent. The WSM requires the breaking of either the time-reversal symmetry (TRS) or the lattice inversion symmetry. When the TRS and inversion symmetry coexist, a pair of degenerate Weyl points may exist, leading to the related Dirac semimetal (DSM) phase. In other words, a DSM can be regarded as two copies of WSMs. At the critical point during the transition from a TI to a normal insulator, the conduction and valence band touching points are the 3D Dirac points or Weyl points and whether the critical points are Dirac or Weyl points depends on whether the inversion symmetry exists or not. This deflection will make the charged particles that are constrained within solid material produce the accumulation of positive and negative charges along the vertical direction of magnetic field, thus forming an additional transverse magnetic field, i.e., that is Hall electric field. Using the measurement device, magnetic flux density distribution could be respectively given the excitation current in solenoid.

Quantum materials hosting Weyl fermions have opened a new era of research in condensed matter physics. First proposed in 1929 in the context of particle physics, Weyl fermions have yet to be observed as elementary particles. In 2015, Weyl fermions were detected as collective electronic excitations in the strong spin–orbit coupled material tantalum arsenide, TaAs. This discovery was followed by a flurry of experimental and theoretical explorations of Weyl phenomena in materials. Weyl materials naturally lend themselves to the exploration of the topological index associated with Weyl fermions and their divergent Berry curvature field, as well as the topological bulk–boundary correspondence, giving rise to protected conducting surface states.

***Bottom Note:*** *This work is partly presented at 2nd International Conference and Exhibition on Mesoscopic and Condensed Matter Physics.*