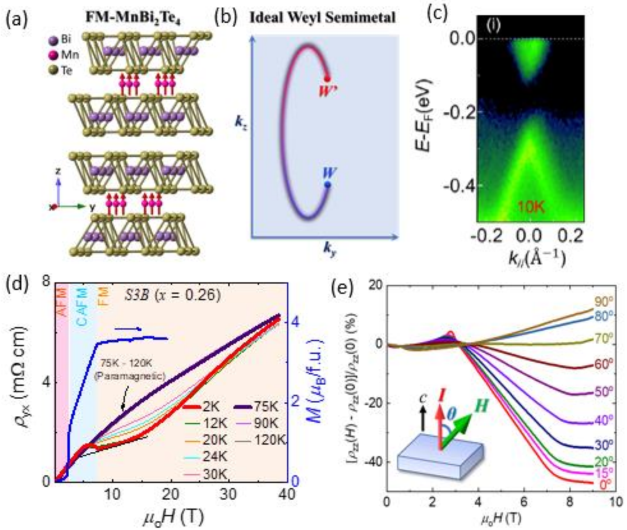
2DCC MIP at Penn State, DMR-1539916
In-House Research - 2021

Evidence for a Magnetic-Field-Induced Ideal Type-II Weyl State in Antiferromagnetic Topological Insulator $Mn(Bi_{1-x}Sb_x)_2Te_4$

Seng Huat Lee, Yanglin Zhu, Hemian Yi, Yuanxi Wang, Ronald Redwing, V. Gopalan, Nitin Samarth, Cui-Zu Chang, Zhiqiang Mao (2DCC, Penn State); Lujin Min, Yi-Fan Zhao, Katrina Verlinde, Jingyang He (Penn State); David Graf, Eun Sang Choi (NHMFL); Samuel Ciocys, Alessandra Lanzara (UC Berkeley); Rabindra Basnet, Arash Fereidouni, Aaron Wegner, Hugh O. H. Churchill, Jin Hu (Arkansas)

Project Summary: The discovery of Weyl semimetals has fueled tremendous interest in condensed-matter physics because they provide not only model platforms for studying concepts in high-energy physics but also a means of realizing technologically relevant exotic quantum states. Although Weyl semimetals have been demonstrated in several nonmagnetic and magnetic materials, one challenge in the current study of Weyl fermion physics is the lack of "ideal" Weyl semimetals. In this study, we found experimental evidence for the simplest ideal Weyl state, induced by magnetic fields in the antiferromagnetic topological insulator $Mn(Bi_{1-x}Sb_x)_2Te_4$ (MBST). We achieve such a Weyl state by tuning the Bi:Sb ratio. When the system is tuned to a state with a small hole concentration, we find the magnetic-field-induced transition from an antiferromagnetic state to a ferromagnetic one causes an electronic structure transition, which leads to transport properties characteristic of a Weyl state: an intrinsic anomalous Hall effect caused by effective magnetic fields in momentum space as well as negative magnetoresistance induced by parallel electric and magnetic fields. These results establish an ideal model system for further understanding of Weyl fermion physics. Published in *Physical Review X* **11**, 031032 (2021).

2DCC Role: All the single crystals used in this study were synthesized using the 2DCC bulk growth facility. The collaboration between the 2DCC bulk growth, theory and characterization teams enables the experimental verification of the predicted field-driven ideal Weyl state in MBST.



(a) Structure of ferromagnetic $MnBi_2Te_4$; (b) illustration of the surface Fermi arc of the ideal Weyl state with one pair of Weyl nodes; (c) angle-resolved photoemission spectra of a lightly electron doped sample; (a) Hall resistivity as a function of field measured on a lightly hole doped sample; (e) the z-axis negative longitudinal magnetoresistance suggestive of the chiral anomaly effect of a Weyl state.