北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Seminar

Topology in Heusler compounds – from a materials perspective

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地点：北京大学物理楼 西563

Abstract

Topological insulators, Weyl metals and Skyrmions are a hot topic in condensed matter physics and materials science. The excitement in the physics community is comparable with the excitement when a new superconductor is discovered. Heusler compounds are a remarkable class of materials with more than 1,000 members and a wide range of extraordinary multifunctionalities [1] including tunable topological insulators (TI) [2] half-metallic high-temperature ferri- and ferromagnets [3], compensated ferrimagnets [4] multiferroic shape memory alloys, and with a high potential for spintronics, energy technologies and magnetocaloric applications. The tunabilty of this class of materials is exceptional and nearly every functionality can be designed. Therefore it is not surprising that we were able to design Heusler compounds with a band inversion and a non-trivial topology for multifunctional TI [2] and Heusler compounds with large anisotropic exchanges and strong Dzyaloshinskii-Moriya interaction [5]. Spontaneous Skyrmion can be found acentric Heusler magnetic compound $Mn_{1.4}PtSn$ [6].

The topological state in these zero-gap semiconductors can be created by applying strain or by designing an appropriate quantum well structure, similar to the case of HgTe. Many of these ternary zero-gap semiconductors (LnAuPb, LnPdBi, LnPtSb and LnPtBi) contain the rare-earth element Ln, which can realize additional properties ranging from superconductivity (for example LaPtBi) to magnetism (for example GdPtBi) and heavy fermion behavior (for example YbPtBi). These properties can open new research directions in realizing the quantized anomalous Hall Effect and topological superconductors. C1b Heusler compounds have been grown as single crystals and as thin films. The control of the defects, the charge carriers and mobilities can be optimized [7]. The band inversion is proven by ARPES [8]. Heusler compounds are similar to a stuffed diamond, correspondingly, it should be possible to find the "high Z"' equivalent of graphene in a graphite-like structure or in other related structure types with 18 valence electrons and with inverted bands [9]. Dirac cones and Weyl points can occur at the critical points in the phase diagrams of TI. Weyl points, a new class of topological phases was predicted in NbP, NbAs and TaP [10]. We founds ultrahigh magneto resistance, mobilities and Fermi arcs in this class, proving their topological electronic state [11].

1. Tanja Graf, Stuart S. P. Parkin, and Claudia Felser, Progress in Solid State Chemistry 39 (2011) 1-50, "Simple Rules for the Understanding of Heusler Compounds"
2. S. Chadov, X. Qi, J. Kübler, G. H. Fecher, C. Felser, S.-C. Zhang, Nature Mater. 2010, 9, 541 "Tunable multifunctional topological insulators in ternary Heusler compounds"
3. M. Jourdan, A. Kronenberg, J. Minar, J. Braun, S. Chadov, B. Balke, A. Gloskovskij, M. Kolbe, H. J. Elmers, G. Schönhense, H. Ebert, C. Felser, and M. Kläui, Nature Com. 5 (2014) 3974 "Direct observation of half-metallicity in the Heusler compound Co_2MnSi"
4. A. K. Nayak, et al. Colossal exchange bias in the artificial antiferromagnetic Mn-Pt-Ga Heusler alloys, Nature Mat. (2015) online.
5. O. Meshcheriakovaet al., Phys. Rev. Lett. 113 (2014) 087203, "Large Noncollinearity and Spin Reorientation in the Novel Mn_2RhSn Heusler Magnet"
6. A. K. Nayak, J. Wild, U. K. Rößler, S. Chadov, A. O. Leonov, W. Carrillo-Cabrera, R. Sahoo, C. Shekhar, O. Meshcheriakova, S. Singh, M. Goyal, F. Damay, M. Nicklas, C. Back, J. van den Brink, J. Zweck, S. S. P. Parkin, C. Felser, Observation of spontaneous skyrmion ground state in Mn-Pt-Sn Heusler material, submitted
7. Chandra Shekhar, Siham Ouardi, Ajaya K. Nayak, Gerhard H. Fecher, Walter Schnelle, and Claudia Felser Phys. Rev. B 86 (2012) 155314 "Ultrahigh mobility and nonsaturating magnetoresistance in Heusler topological insulators"
8. Z. K. Liu, L. X. Yang, S. –C. Wu, B. Zhou, Y. Zhang, S. –K. Mo, Z. Hussain, Z. X. Shen3, B. H. Yan, Chandra Shekhar, C. Felser and Y. L. Chen, submitted "Unusual Topological Surface States in Half-Heusler Compounds LnPtBi (Ln=Lu, Y)"
9. B. Yan, L. Müchler, C. Felser, Phys. Rev. Lett. 2012, 109, 116406 "Prediction of weak topological insulators in layered semiconductors"
10. C. Shekhar, A. K. Nayak, Y. Sun, M. Schmidt, M. Nicklas, I. Leermakers, U. Zeitler, Y. Skourski, J. Wosnitza, W. Schnelle, H. Borrmann, W. Schnelle, J. Grin, C. Felser, B. Yan, Nat. Phys. under review preprint arXiv:1502.04361 "Extremely large magnetoresistance and ultrahigh mobility in the topological Weyl semimetal NbP"
11. Yulin Chen et al. to be published

About the Speaker

Prof. Claudia Felser studied chemistry and physics at the University of Cologne (Germany) and completed her doctorate in physical chemistry there in 1994. After postdoctoral fellowships at the MPI in Stuttgart and the CNRS in Nantes (France), she joined the University of Mainz and became a full professor at the University of Mainz (Germany) in 2003. She was a visiting scientist at Princeton University (USA) in 1999 and at Stanford University in 2009/2010 and a visiting professor at the University of Caen (France). In Dec. 2011, she became director at the Max Planck Institute for Chemical Physics of Solids in Dresden (Germany). She is the chair of the DFG research group "New Materials with High Spin Polarization" and was the director of the Graduate School of Excellence "Materials Science in Mainz" of the German Science Foundation (DFG) from 2007-2012.