Noncollinear magnetic order in epitaxial thin films of Heusler compounds

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Magnetic systems exhibiting spin-canted states have garnered much attention recently for their promising rich exotic properties driven by the real-space spin textures and competing magnetic orders. Thin films and single crystals of the noncentrosymmetric inverse tetragonal Heusler compounds Mn_2RhSn and Mn_xPtSn ($x = 1.4–2$) were found to host a variety of nontrivial magnetic structures, ranging from elliptical skyrmions to antiskyrmions and noncoplanar spin textures [1-4]. This phenomenon, to host multiple topological spin textures, is especially interesting for applications when observed through real-space imaging techniques, such as magnetic force microscopy (MFM), and transport signatures. One such transport signature is the topological Hall effect (THE), which is a transverse response to an applied current, and it is distinct for each topological texture. These THE's can be generally be classified in the size of the magnetic texture and the strength of coupling to the magnetic texture. In this work, we present the magnetic and magnetotransport properties of high-quality epitaxial thin films of the tetragonal Mn_xPtSn and Mn_2RhSn, and the hexagonal MnPtGa Heusler compounds. We show that the Mn_xPtSn displays two magnetic regions, a collinear state above the spin reorientation and noncoplanar below. We have measured THE and anomalous Hall effect (AHE) in these regions and they remarkably show the same magnitude. Further, we tune the Mn content (x), which allows for microscopic control of the magnetic exchange parameters (Fig. 1a). With our thin film method, we can access a novel and fundamental understanding of this compound not possible with other methods. We show a microscopic control of the exchange parameters that influence the size of the magnetic textures and thereby the transport signatures. Furthermore, in Mn_2RhSn films, we observe two peaks in the THE, which allow us to determine the existence of two distinct topological objects over a wide range of temperature and magnetic fields (Fig. 1b) [3,4]. Finally, in the hexagonal MnPtGa films, we find that below a thermally induced spin reorientation transition at 160 K, the magnetic groundtstate, determined by a single-crystal neutron diffraction, is a noncollinear spin canted state where the Mn moments tilt 20° away from the c-axis (Fig. 1c) [5].

References

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Figures

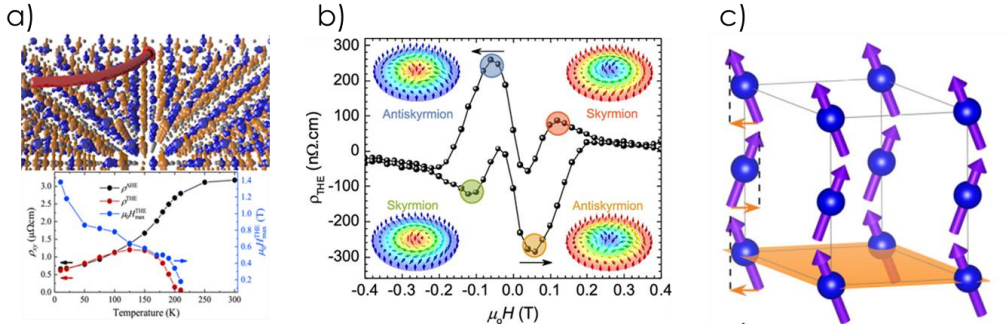

Figure 1: THE in Mn_xPtSn (a) and Mn_2RhSn (b) films. c) Noncollinear magnetic groundstate of MnPtGa.