Electrical manipulation of an anomalous Hall effect in the Weyl antiferromagnet Mn_3Sn

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There has been a surge of interest in antiferromagnetic (AF) materials due to their favorable properties for device applications including a vanishingly small stray field, faster spin dynamics, and more abundance in nature compared to their ferromagnetic counterparts. In fact, motivated by these intriguing properties, several breakthroughs have been made: an anisotropic magnetoresistance and spin Hall magneto resistance (even-function response under time-reversal (TR)) for detecting collinear AF ordering [1]. Another breakthrough is an odd-function response under TR in the non-collinear antiferromagnetic metal Mn_3Sn such as an anomalous Hall effect (AHE) [2], anomalous Nernst effect (ANE) [3], and magneto-optical Kerr effect (MOKE) [4] at zero magnetic field. Moreover, both theoretical and experimental studies have revealed that Mn_3Sn is a TR symmetry breaking Weyl material (Weyl magnet) possessing a large and controllable Berry curvature (fictitious field) in the momentum space because of its unique magnetic and topological electronic structure, which give rise to the large TR-odd responses [5].

In this study, we performed the electrical switching of an antiferromagnetic spin texture and its detection by AHE at room temperature in a polycrystalline thin film of the Weyl antiferromagnet Mn_3Sn [6]. Using bilayer devices composed of Mn_3Sn and nonmagnetic heavy metals (Pt and W), we found that an electrical current density in nonmagnetic metals of about 10^{10} to 10^{11} A/m^2 can induce magnetic switching with a large change in Hall voltage due to the spin-orbit torque. Moreover, transport measurements of the Mn_3Sn thin films [7] revealed that (1) the angular dependence of the magneto-conductivity and planar Hall conductivity is well fitted by the theoretical equations for the chiral anomaly, and (2) the anomalous Nernst and transverse thermoelectric coefficients are larger than that expected from the empirical scaling law with magnetization, which should provide evidence for the presence of Weyl points near the Fermi energy producing the large Berry curvature. These results indicate that the electrical switching of the AHE signal in the Mn_3Sn thin film corresponds to electrical manipulation of the topological antiferromagnetic state and of the distribution of Weyl points in momentum space.

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