Coexistence of Anomalous Hall Effect and Weak Magnetization in Nominally Collinear Antiferromagnet MnTe

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In contrast to ferromagnetic systems, where magnetization governs the anomalous Hall signal, the origin of the anomalous Hall effect (AHE) in compensated, antiferromagnetic materials remains still unsettled. While in various material systems an antiferromagnetic phase was found to coexist with a weak ferromagnetic signal, symmetry-based theoretical predictions indicate a possibility of a non-zero AHE even in the absence of sample magnetization. In particular hexagonal MnTe is case of collinear antiferromagnets, where the AHE and no detectable magnetization have been recently reported [1–3].

To solve the fundamental problem of origin of the AHE in antiferromagnets, we design a comprehensive study of hexagonal MnTe samples combining experiment and theory. We employ substrate-free bulk samples, with current paths along different crystal directions in the hexagonal lattice, in which undesired parasitic or background effects related to the substrate are absent. We demonstrate that the existence of the AHE in the hexagonal MnTe is accompanied by the presence of a weak, but detectable, perpendicular to the basal plane of the hexagonal unit cell ferromagnetic signal, vanishing at the Néel temperature [4]. In contrast to thin layer samples [3], we find that the hysteresis loop shows an opposite sign and Barkhausen-like jumps. We introduce a macrospin model involving the Dzyaloshinskii–Moriya type interaction, which explains the existence of a non-zero magnetic moment in the absence of external field and reproduces well hysteretic behavior of the AHE. Moreover, by the Berry curvature analysis we show that the AHE in hexagonal MnTe is non-zero even when the magnetization vanishes. We argue that there is a common, symmetry-related origin of both the AHE and this weak ferromagnetic signal.

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