Observation of Temperature Independent Anomalous Hall Effect in Thin Bismuth from Near Absolute Zero to 300 K Temperatures

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The anomalous Hall effect (AHE) has been extensively studied for more than a century, and the different origins of the AHE have only been well understood recently. Notably, the intrinsic type of the AHE that was first proposed by Karplus and Luttinger is now reconciled with the presence of a Berry curvature, whereas the extrinsic types of the AHE emerge from scattering mechanisms due to impurities. On the other hand, bismuth, a fascinating material for discovering new exotic phenomena like the Shubnikov-de Haas and Nernst-Ettingshausen effects, is a topic of recent interest, particularly due to its 2D limit, bismuthene, where there are substantial evidences for it to be a higher order topological insulator (HOTI) [1, 2]. However, one would least expect the diamagnetic bismuth to exhibit the AHE where either origin would require broken time-reversal symmetry (TRS) that only typically occur in ferromagnetic systems.

In our work, we developed a novel mechanical exfoliation method to isolate thin bismuth flakes down to 2 nm [3]. With this technique, we fabricated thin bismuth devices of thicknesses ranging from 29 to 69 nm where we unambiguously observed the AHE accompanied with a longitudinal resistance absent of any magnetoresistance up to $\pm$30 T [4, 5]. Most importantly, these behaviors show a negligible temperature dependence between 15 mK to 300 K. Such absence of temperature dependence lends support that there exists a hidden mechanism for breaking the TRS in bismuth and the observed AHE here is indeed intrinsic in nature [4, 5].

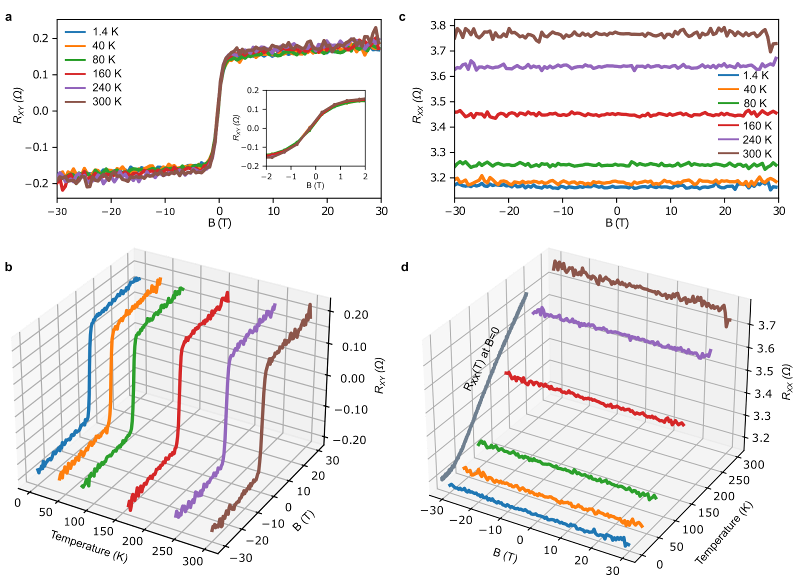

Fig. 1. **Temperature and magnetic field dependences of the Hall and longitudinal resistances for a 68 nm device. a**, Hall and **c**, longitudinal resistances as a function of the magnetic field at various temperatures ranging from 1.4 K to 300 K. The inset in **a** is the zoom-in for the data between $\pm$2 T. **b**, **d**, 3D plots of the same curves in **a** and **c** respectively.

References

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