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

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Bismuth has been an archetypal material for discovering new physical phenomena. Notably, it has led to the observation of diamagnetism by Faraday and later on the Nernst-Ettingshausen effect and Shubnikov-de Haas oscillations.

Propelled by its potential for new discoveries and the renewed interest for bismuthene (*i.e.,* the 2D limit of bismuth), we developed an innovative mechanical exfoliation technique to fabricate thin bismuth Van der Pauw devices of thicknesses ranging from 29 to 69nm **(see Figs. 1(a) and 1(b)).** Preliminary results in a 9T system at 15mK unravelled the presence of a *bona fide* anomalous Hall effect (AHE) in our thin bismuth device. The MagLab 31T resistive magnet equipped with a variable temperature insert allowed us to widely extend the measurement range. As a result, *we surprisingly observed that the AHE is independent of temperature from 1.4 to 300K* **(see Fig. 1(c))** and that the magnetoresistance is featureless from -30 to 30T **(see Fig. 1(d)).**

Both results are puzzling, especially since bismuth is known to be diamagnetic and the AHE requires time reversal symmetry to be broken which typically occurs in ferromagnetic materials. Furthermore, the absence of temperature dependence supports an interpretation of the AHE as being of an intrinsic nature, known to be a precursor of the quantum anomalous Hall effect. Given its buckled honeycomb crystal structure and high degree of spin-orbit coupling, bismuth could be a promising platform to explore the parity anomaly predicted by Haldane and leads us to speculate whether the quantum anomalous Hall effect could be observed at higher temperature than it has been so far.

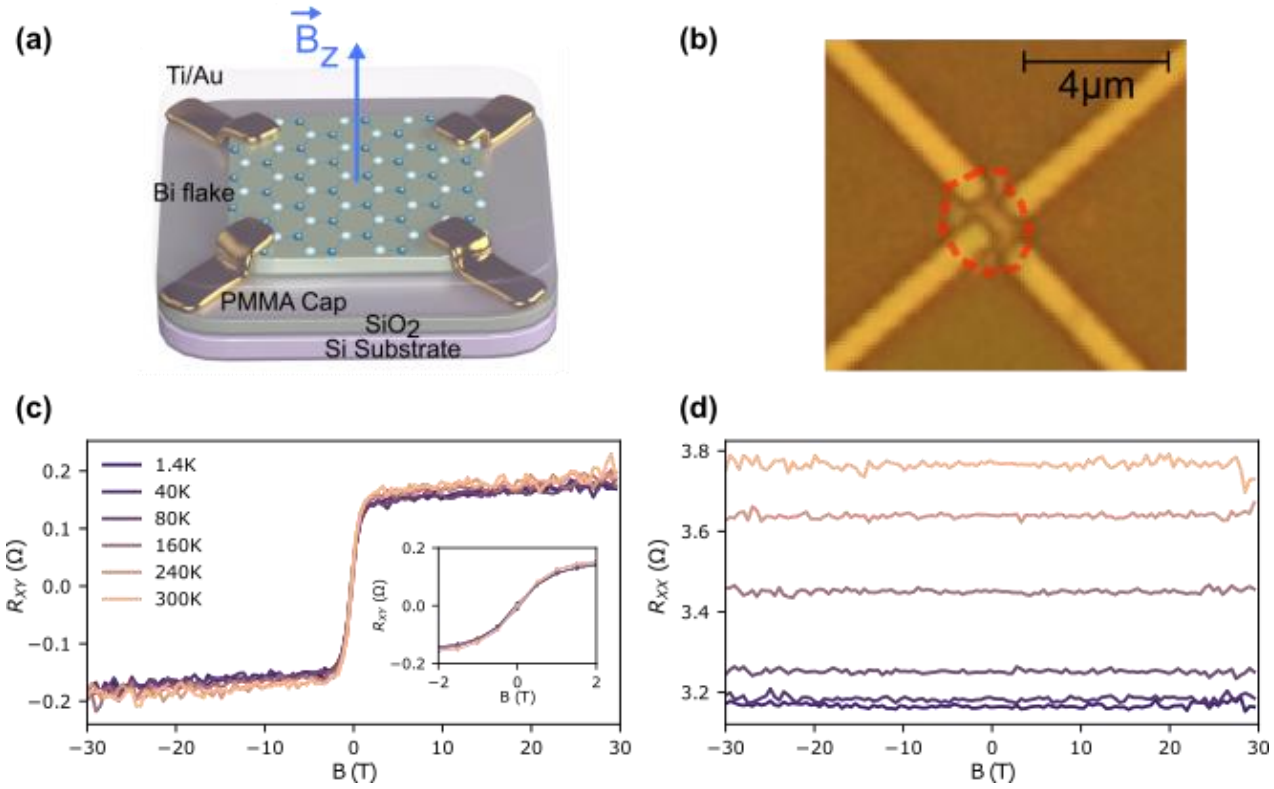

Fig. 1: (a) Schematic and **(b)** optical image of the thin bismuth device. **(c)** Hall and longitudinal responses for temperatures ranging from 1.4 to 300K.

Facilities and instrumentation used: DC field, 31 Tesla, 50 mm bore resistive magnet, cell 9
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