Giant Anomalous Hall Effect in quasi-2D Layered Antiferromagnet $Co_{1/3}NbS_2$

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The discovery of the anomalous Hall effect (AHE) in bulk metallic antiferromagnets (AFMs) motivates the search of the same phenomenon in two-dimensional (2D) systems, where a quantized anomalous Hall conductance can in principle be observed [1]. Here, we present experiments on micro-fabricated devices based on $Co_{1/3}NbS_2$, a layered AFM that was recently found to exhibit AHE in bulk crystals [2] below the Néel temperature T_N = 29 K. Transport measurements reveal a pronounced resistivity anisotropy, indicating that upon lowering temperature the electronic coupling between individual atomic layers is increasingly suppressed. The experiments also show an extremely large anomalous Hall conductivity of approximately 400 S/cm, more than one order of magnitude larger than in the bulk, which demonstrates the importance of studying the AHE in small exfoliated crystals, less affected by crystalline defects. Interestingly, the corresponding anomalous Hall conductance, when normalized to the number of contributing atomic planes, is ~0.6 e^2/h per layer, approaching the value expected for the quantized anomalous Hall effect. The observed strong anisotropy of transport and the very large anomalous Hall conductance per layer make the properties of $Co_{1/3}NbS_2$ compatible with the presence of partially filled topologically non-trivial 2D bands originating from the magnetic superstructure of the antiferromagnetic state. Isolating atomically thin layers of this material and controlling their charge density may therefore provide a viable route to reveal the occurrence of the quantized AHE in a 2D AFM.

References

[1] I. Martin and C. D. Batista, Physical Review Letters 101, 156402 (2008).

[2] N. J. Ghimire, A. S. Botana, J. S. Jiang, J. Zhang, Y. S. Chen, and J. F. Mitchell, Nature Communications 9, 1 (2018).

Figures

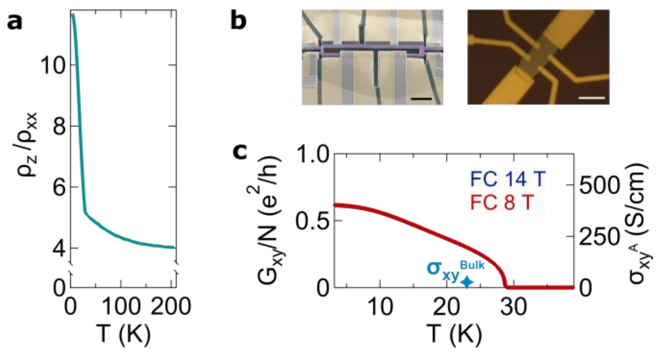

Figure 1 a, Temperature dependence of the ratio between the resistivity out-of-plane ρ_z and the resistivity in-plane ρ_{xx} measured in micro-fabricated devices. **b,** Optical micrographs of representative devices (the scale bar is 20 μm and 5 μm for left and right image, respectively). **c,** Temperature evolution of the zero-field anomalous Hall conductance G_{xy} normalized to the number of atomic layers of the exfoliated crystal, measured upon field cooling (FC) in 8 T and 14 T.