Study discovers non-reciprocal antisymmetric transport behavior in natural van der Waals ferromagnetic material

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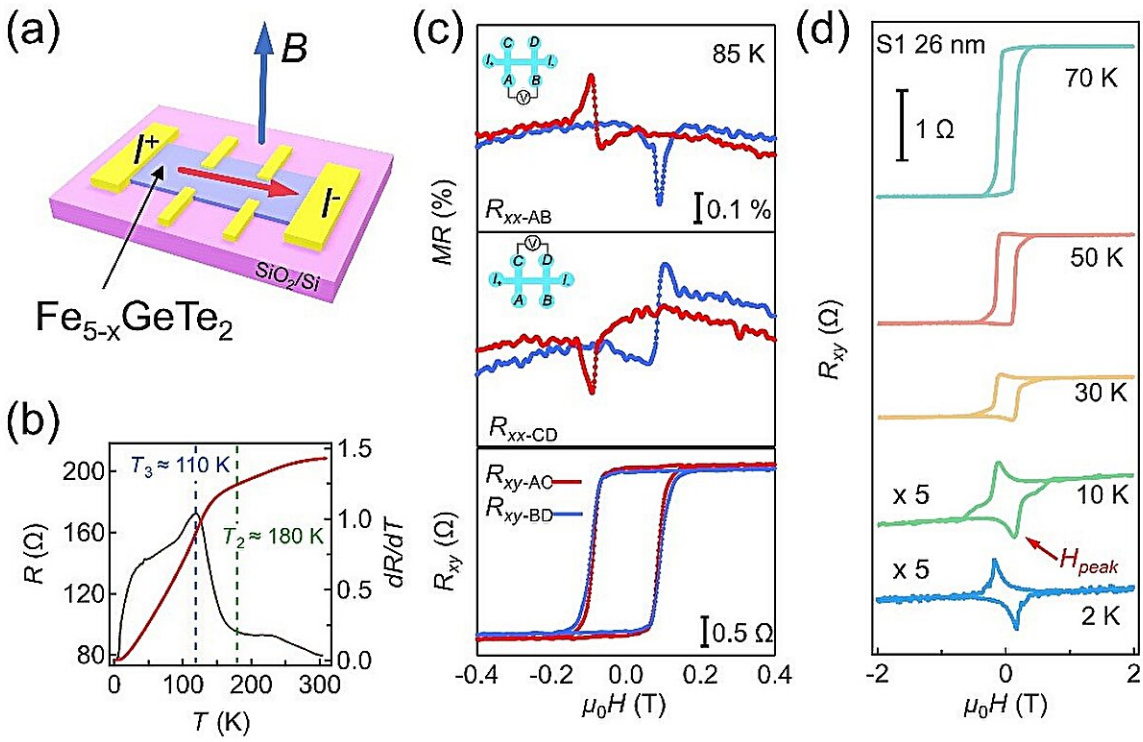

Transport properties of the $Fe_{5-x}GeTe_2$ nanodevice. Credit: Miao Weiting

According to a study published in *ACS Nano*, a research team has revealed a novel non-reciprocal antisymmetric magnetoresistance and unconventional Hall effect in a two-dimensional (2D) van der Waals

(vdW) ferromagnetic $Fe_{5-x}GeTe_2$, which may originate from the asynchronous magnetization switching of the magnetic domains.

2D ferromagnets with high Curie temperatures provide a rich platform for exploring the exotic phenomena of 2D magnetism and the potential of spintronic devices. As a typical layered ferromagnetic material, $Fe_{5-x}GeTe_2$ has attracted intensive attention due to its high Curie temperature. However, due to its complex magnetic ground state and magnetic domains, there is still a lack of thorough understanding of the transport behavior related to its lattice and domain structures.

In this work, the researchers led by Prof. Tian Mingliang from the Hefei Institutes of Physical Science of the Chinese Academy of Sciences, synthesized high-quality single crystals of the room-temperature ferromagnetic $Fe_{5-x}GeTe_2$ and systematically measured its magnetotransport properties. In bulk samples of $Fe_{5-x}GeTe_2$, the results show a magnetic easy axis switching from in-plane to out-of-plane direction as temperature decreases.

To further explore the interplay between its magnetic structure and magnetotransport properties, $Fe_{5-x}GeTe_2$ nanosheets with thicknesses ranging from 7 nm to 50 nm were obtained by mechanical exfoliation.

"As the sample thickness decreased, the magnetic transport behavior of the confined $Fe_{5-x}GeTe_2$ nanosheets exhibited completely different characteristics, indicating a significant thickness dependence of the magnetic properties of this system," said Miao Weiting, a member of the team.

This study has revealed a novel non-reciprocal antisymmetric magnetoresistance and unconventional Hall effect in the presence of a magnetic field. Through precise analysis of its temperature, field orientation, and sample thickness dependence, it can be attributed to the

additional electric field contribution of the stripe domain structure to the magnetoresistance in the material.

This work demonstrates that the micromagnetic structure of the system has a significant impact on its macroscopic electrical transport characteristics, thus providing a deeper understanding of 2D ferromagnetic materials and opening new avenues for device application.

More information: Weiting Miao et al, Nonreciprocal Antisymmetric Magnetoresistance and Unconventional Hall Effect in a Two-Dimensional Ferromagnet, *ACS Nano* (2023). DOI: 10.1021/acsnano.3c08954

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