

Anomalous nonlinear magnetoconductivity in van der Waals magnet CrSBr

Fèlix Casanova

Junhyeon Jo, Manuel Suárez-Rodríguez, Samuel Mañas-Valero, Eugenio Coronado, Ivo Souza, Fernando de Juan, Marco Gobbi, and Luis E. Hueso

CIC nanoGUNE BRTA, 20018 Donostia-San Sebastian, Basque Country, Spain

f.casanova@nanogune.eu

Electrical transport in non-centrosymmetric materials departs from the well-established phenomenological Ohm's law. Non-linear transport effects, characterized by a quadratic relationship between voltage and current, can arise in these systems, either with or without external magnetic fields [1]. These effects are fundamentally tied to the absence of spatial inversion symmetry. One of them is nonlinear magnetoconductivity (NLMC), also known as unidirectional magnetoresistance, bilinear magnetoresistance, or electrical magnetochiral anisotropy, which we showed that can be used to distinguish the handedness of chiral materials such as Te [2].

However, this ordinary NLMC signal vanishes at zero magnetic field, limiting its potential for applications. Here, the observation of an anomalous NLMC controlled by internal order parameters such as the magnetization or Néel vectors is reported [3]. This response is achieved by breaking both inversion and time-reversal symmetry in artificial van der Waals heterostructures based on the magnetic CrSBr and insulating hBN. The nonreciprocal signal can be tuned between two different states in ferromagnetic (FM) monolayer CrSBr and among four different states in antiferromagnetic (AFM) bilayer CrSBr, thanks to its metamagnetic transition. Remarkably, this output signal in the FM (AFM) state of CrSBr is three (one) orders of magnitude higher than those previously measured. A conductivity scaling analysis reveals the Berry connection polarizability as the origin of the anomalous NLMC. The results pave the way for high-frequency rectifiers with magnetically switchable output polarity as well as for an efficient electrical readout of the magnetic state of AFM materials.

References

- [1] M. Suárez-Rodríguez, FC et al., Nat. Mater. 24, 1005-1018 (2025)
- [2] F. Calavalle, FC et al., Nat. Mater. 21, 526-532 (2022).
- [3] J. Jo, FC et al., Adv. Mater. 37, 2419283 (2025).

Figures

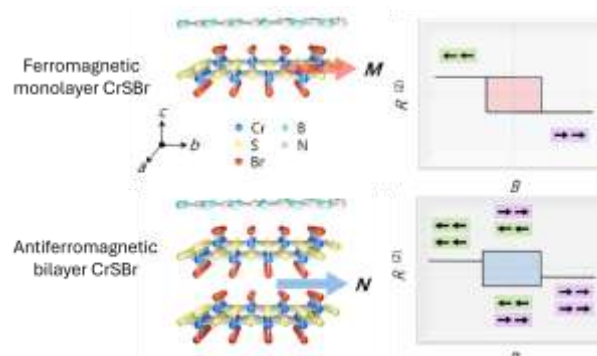


Figure 1: Anomalous NLMC response in ferromagnetic monolayer and antiferromagnetic bilayer CrSBr