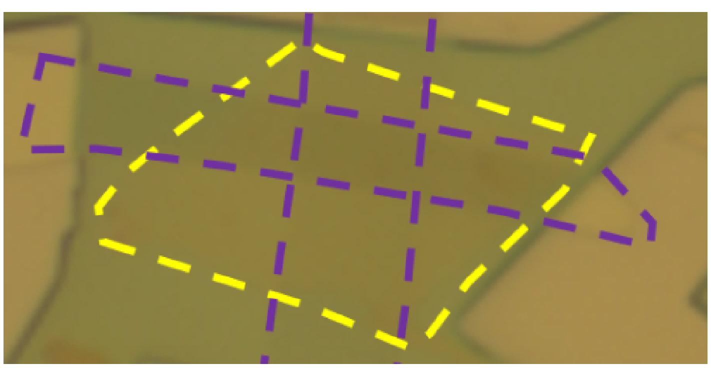
Oscillating Magnetoresistance

At low temperatures the resistance of a layered magnetic semiconductor shoots up and down in response to an increasing magnetic field.

By **Charles Day**

People who design electronic devices would love a semiconductor that responds not just to an applied electric field but also to a magnetic field. So-called van der Waals magnets appear promising. These semiconductors consist of stacks of weakly bound 2D magnetic layers of alternating, or antiferromagnetic, polarity. However, their conduction bands tend to be so narrow that the crowded electrons struggle to move; they are not good semiconductors. An exception was identified in 2023 by Alberto Morpurgo of the University of Geneva and his collaborators, who found that the van der Waals magnet $CrPS_4$ has unusually wide bands and a large magnetic dependence in the material's resistance [**1**]. Morpurgo and his team have now explored this magnetoresistance further. They discovered that under certain conditions the magnetoresistance oscillates—that is, it goes up and down as the applied magnetic field increases [**2**]. This unexpected oscillatory behavior, the researchers say, illustrates the need to better understand the nature of transport through van der Waals magnets.

The researchers sandwiched thin slabs of $CrPS_4$ of various thicknesses between graphene electrodes. They then measured the current through the devices as they varied the temperature, applied magnetic field, and applied voltage. They found that the magnetoresistance disappeared when the voltage was large, as the electrons piled into the conduction band. But at intermediate voltage values, electrons could not reach the conduction band. They became trapped in defect states in the band gap. The electrons could still hop from one thin antiferromagnetic layer to the next, thereby constituting a current, but the hopping became harder or easier—and the resistance higher or lower—depending on how the applied magnetic field reoriented the polarity of the antiferromagnetic layers.



Credit: A. Morpurgo/University of Geneva

Charles Day is a Senior Editor for ***Physics Magazine***.

REFERENCES

1. F. Wu *et al.*, "Magnetism-induced band-edge shift as the mechanism for magnetoconductance in $CrPS_4$ transistors," **Nano. Lett. 23, 8140 (2023).**
2. X. Lin *et al.*, "Positive oscillating magnetoresistance in a van der Waals antiferromagnetic semiconductor," **Phys. Rev. X 15, 011017 (2025).**