(Invited) Spontaneous topological Hall effect induced by non-coplanar antiferromagnetic order in intercalated van der Waals materials CoTa3S6 and CoNb3S6

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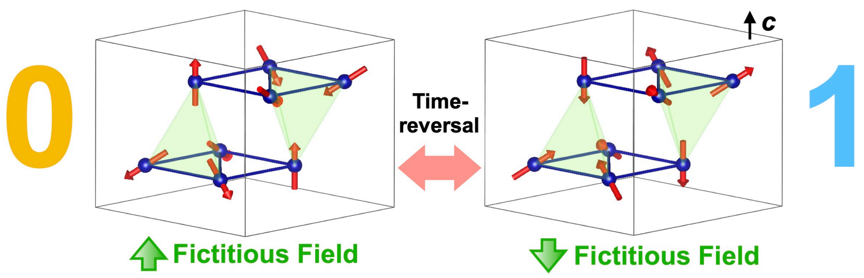
Topological spin texture |

In ferromagnets, electric current generally induces a transverse Hall voltage in proportion to the internal magnetization. This effect is frequently used for electrical readout of the spin up and down states. While these properties are usually not expected in antiferromagnets, recent theoretical studies predicted that non-coplanar antiferromagnetic order with finite scalar spin chirality -- meaning a solid angle spanned by neighboring spins -- can induce a large spontaneous Hall effect even without net magnetization or external magnetic field. This phenomenon, the spontaneous topological Hall effect, can potentially be used for the efficient electrical readout of the antiferromagnetic states, but it has not been experimentally verified due to a lack of appropriate materials hosting such magnetism. Here, we report the discovery of all-in-all-out type non-coplanar antiferromagnetic order in triangular lattice compounds CoTa3S6 and CoNb3S6. These compounds are reported to host unconventionally large spontaneous Hall effect despite their vanishingly small net magnetization, and our analysis reveals that it can be explained in terms of the topological Hall effect that originates from the fictitious magnetic field associated with scalar spin chirality. These results indicate that the scalar spin chirality mechanism offers a promising route to the realisation of giant spontaneous Hall response even in compensated antiferromagnets, and highlight intercalated van der Waals magnets as a promising quasi-two-dimensional material platform to enable various nontrivial ways of electrical reading and possible writing of non-coplanar antiferromagnetic domains[1].



Two possible antiferromagnetic domains realized in CoTa3S6, which are converted into each other by time-reversal operation and characterized by the opposite sign of fictitious magnetic field.

References

[1] H. Takagi, S. Seki *et al.*, Nature Physics **19**, 961 (2023).