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Complex magnetic orders and the emergent topological Hall effect in the kagome metal $ErMn_6Sn_6$

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Following the discovery of a quantum-limit magnetic Chern phase in $TbMn_6Sn_6$ [1], and the observation of a large topological Hall effect (THE) related to the field-induced magnetic phases in YMn_6Sn_6 [2], the magnetic topological metal series RMn_6Sn_6 (R=Gd-Yb, and Y, Lu etc.) [3], that possess an ideal kagome lattice of Mn, have emerged as a new platform to explore exotic states and novel functionalities. We have recently carried out the growth of high-quality single crystals of the magnetic kagome metal $ErMn_6Sn_6$ via the flux method, and the physical properties characterizations via the magnetic susceptibility, heat capacity and Hall conductivity measurements. We have also undertaken comprehensive neutron diffraction experiments on both single-crystal and powder samples at the WISH diffractometer at ISIS. A number of distinct magnetic ordered phases, including the spiral, conical and $k = 0$ magnetic orders, have been identified in cooling to low temperatures. Furthermore, we have also observed a range of complex field-induced magnetic phases, including the multi-k non-coplanar magnetic orders, via field-dependent single-crystal neutron diffraction at WISH. We have found that these complex field-induced magnetic phases are directly associated to our observed THE over a wide phase space of field and temperature in this compound. Our study has clearly hinted a fascinating interplay between topologically non-trivial electronic band structures, magnetism and electronic correlations in $ErMn_6Sn_6$.
[1] J. X. Yin, *et al.*, Nature **583**, 533 (2020).
[2] N. J. Ghimire, *et al.*, Sci. Adv. **6**, eabe2680 (2020).
[3] W. Ma, *et al.*, Phys. Rev. Lett. **126**, 246602 (2021).

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