Defect Mediated Helical Phase Reorientation by Uniaxial Stress

Tae-Hoon Kim,[1] Haijun Zhao,[1,2] Liqin Ke,[1] Lin Zhou[1,3,+]

1 Ames National Laboratory, U.S. Department of Energy, Ames, Iowa 50011, USA
2 Department of Physics, Key Laboratory of MEMS of the Ministry of Education, Southeast University, Nanjing 211189, China
3 Department of Materials Science and Engineering, Iowa State University, Ames, Iowa 50011, USA

Chiral magnetism has attracted extensive research attention due to its fundamental science and technological importance. In chiral magnet domains, the competition between exchange and Dzyaloshinskii–Moriya interaction (DMI) causes the spins to wind periodically on a plane either perpendicularly (helix) or with a canting angle (cone) along a specific direction, defined as a propagation vector (Q) [1]. Strain engineering enables precise control of nanoscale magnetism while minimizing energy consumption [2]. However, the spatial evolution of strain-induced spin rearrangement, critical for deterministic control of chiral magnetic structures, remains unclear.

In this study, we utilize in-situ Lorentz transmission electron microscopy to manipulate and monitor the reorientation of the helical phase under quantitatively applied uniaxial tensile stress. Our results demonstrate that the Q vector direction of the helical phase can be tuned using external stress. The underlying mechanisms that govern the spin reorientation are magnetic defect mediated, which involve either "break-and-reconnect" events, or dislocation gliding and annihilation within the helices. Simulations prove that the strain-induced anisotropic DMI plays a significant role in driving the reorientation of the helical phase. Our findings provide valuable insights into energy-efficient manipulation of magnetic nanophase for information technology.

[1] Schoenherr, P. et al. Topological domain walls in helimagnets. Nat. Phys. **14**, 465 (2018).
[2] Wang, J. Mechanical Control of Magnetic Order: From Phase Transition to Skyrmions. Annu. Rev. Mater. Res. **49**, 1 (2019).

[+] Author for correspondence: linzhou@iastate.edu