

Photothermal dynamics around a magnetic edge dislocation visualized by pump-probe Lorentz TEM

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Chiral magnets host periodic helical spin structures originating from the competition between the exchange interaction and Dzyaloshinskii-Moriya interaction, in which topological defects such as magnetic edge dislocations can emerge [1]. These defects exhibit rich dynamics under external stimuli, including motion, creation, and annihilation, and are considered to play an important role in magnetic phase transitions and domain evolution [2, 3]. However, ultrafast defect-mediated processes in photoinduced magnetic phase transition remain poorly understood, since direct observation of nonequilibrium dynamics of nanoscale topological defects remains challenging.

In this work, we investigate the photothermally induced helical-to-paramagnetic phase transition in $\text{Co}_9\text{Zn}_9\text{Mn}_2$ [4] using pump-probe Lorentz transmission electron microscopy (Lorentz TEM) with nanometer-nanosecond spatiotemporal resolution. Following the suppression of magnetic stripe contrast induced by the femtosecond pulsed laser excitation, we observe a directional recovery driven by anisotropic thermal diffusion toward the sample edge working as an effective heat sink. Remarkably, around a magnetic edge dislocation, the magnetic contrast recovery exhibits a pronounced delay accompanied by a significant transient blurring of Lorentz TEM contrast. These findings suggest that the recovery dynamics around the magnetic edge dislocation proceed through multiple relaxation paths that are selected stochastically, including the slipping motion of the magnetic edge dislocation. Our results reveal a possible enhancement of stochasticity around topological defects during the recovery dynamics of magnetic phase transitions.

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[3] P. Schoenherr *et al.*, ACS Nano **15**, 17508 (2021).

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