

Néel vector rotation via hole doping in RuO₂ thin films

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Since the introduction of the concept of altermagnetism [1], RuO₂ has attracted considerable attention as a candidate altermagnet and a platform for spintronic experiments. While the magnetic ground state of stoichiometric RuO₂ remains controversial depending on the characterization methods and the sample details, new focus has been made on whether RuO₂ can be driven to altermagnetism by external parameters. Hole doping and the resulting Néel vector rotation have been proposed as one such route, and anomalous Hall effect via hole-doping in Cr-doped RuO₂ thin films has been reported [2]. However, Cr-doping can lead to formation of ferromagnetic CrO₂, making it challenging to identify the hole doping effect on altermagnetism through anomalous Hall effect [3].

In this study, we investigated Fe-doped RuO₂ thin films to clarify the correlation between the Fermi level shift and Néel vector rotation. Fe can nominally introduce hole when being incorporated as Fe³⁺ on Ru⁴⁺ sites. Fe_xRu_{1-x}O₂ (110) thin films with various Fe concentration x were grown on TiO₂ (110) substrates using pulsed laser deposition technique, and Hall response was measured. As shown in Fig. 1, we found that the Hall coefficient at 2 K changes from positive to negative with increasing Fe content. This systematic variation is considered to originate from the shift of the Fermi energy induced by Fe doping, which correlates to the magnetocrystalline anisotropy and facilitates the Néel vector rotation.

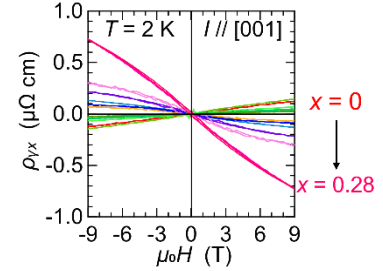


Fig. 1 Magnetic field dependence of the Hall resistivity in the Fe_xRu_{1-x}O₂ (110) films at $T = 2$ K.

[1] L. Šmejkal *et al.*, *Beyond Conventional Ferromagnetism and Antiferromagnetism: A Phase with Nonrelativistic Spin and Crystal Rotation Symmetry*. Phys. Rev. X **12**, 031042 (2022).

[2] M. Wang *et al.*, *Emergent zero-field anomalous Hall effect in a reconstructed rutile antiferromagnetic metal*. Nat. Commun. **14**, 8240 (2023).

[3] A. Smolyanyuk *et al.*, *Origin of the anomalous Hall effect in Cr-doped RuO₂*. Phys. Rev. B **111**, 064406 (2025).