

Electric field-induced Nonreciprocal Directional Dichroism of $\text{DyFe}_{1-x}\text{Al}_x\text{O}_3$

W. Asahara¹, K. Arakawa², T. Hayashida³, T. Nagai¹, and T. Kimura¹

¹*Dept. of Appl. Phys., Univ. of Tokyo*

²*Dept. of Adv. Mater. Sci., Univ. of Tokyo*

³*HFML-FELIX, Radboud Univ.*

Altermagnets have recently attracted considerable attention for exhibiting phenomena previously thought to be caused by ferromagnetism. Recently, a new characteristic optical phenomenon, “electric field-induced nonreciprocal directional dichroism (ENDD),” was reported [1]. ENDD is a phenomenon in which the light absorption coefficient changes upon the application of an electric field.

The orthorhombic perovskite DyFeO_3 (space group $Pbnm$) studied in this work exhibits weak ferromagnetism (Γ_4 phase: magnetic point group $m'm'm$) at room temperature. It undergoes a spin-reorientation transition at $T_{\text{SR}} = 50$ K, transforming into an antiferromagnetic phase without net magnetization (Γ_1 phase: magnetic point group mmm). A previous study reported domain imaging by ENDD in the Γ_1 phase within the visible light region [2]. In this study, we performed ENDD measurements on single crystals of DyFeO_3 in the visible and the near-infrared region—where Fe^{3+} d - d and Dy^{3+} f - f transitions dominate, respectively. Also, in the geometry of $\mathbf{k} \parallel \mathbf{E} \parallel [110]$, ENDD was observed in both Γ_1 and Γ_4 phases as well as reported in ErCrO_3 [3]. By investigating spectral and imaging characteristics, we examine the microscopic origin of ENDD in this material.

In addition, we synthesized single crystals of $\text{DyFe}_{1-x}\text{Al}_x\text{O}_3$ and found that doping Al^{3+} into Fe^{3+} site increases T_{SR} ($T_{\text{SR}} = 133$ K at $x = 0.2$). By observing ENDD, we successfully visualized the spatially uniform antiferromagnetic domains. These results suggest that magnetic order identical to that of DyFeO_3 is maintained even in the presence of high concentrations of nonmagnetic ion substitutes.

[1] T. Hayashida, K. Matsumoto, and T. Kimura, *Adv. Mater.* **37**, 2414876 (2025).

[2] K. Kobayashi, T. Hayashida, and T. Kimura, *npj Quantum Mater.* **11**, 38 (2026).

[3] K. Matsumoto, T. Hayashida, and T. Kimura, *Phys. Rev. Lett.* **136**, 216703 (2026).