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## Spiral Spin Structure in Dy-Doped Spinel-Ferrite

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Noncollinear spin structures have received tremendous interest in recent years as they provide a versatile platform for spin control and manipulation desirable for spintronics<sup>1</sup>. Realization of noncollinearity in ferrimagnetic insulators is of particular interest as the combined effect of both ferro- and antiferromagnetic orders opens up opportunities for their potential utilization in low-damping spintronic devices with desirable magnetic order and minimal stray fields<sup>2</sup>.

Inverse spinel nickel ferrite is a classical ferrimagnetic insulator with a collinear in-plane magnetic structure<sup>3</sup>. The substitution of Zn and Al in the nickel ferrite (NiZAF) makes it an excellent choice especially for low-damping spintronics<sup>4</sup>. However, the realization of noncollinearity together with low-damping has remained challenging so far. Here we show

the evidence of noncollinearity in the ultrathin films (3-5 nm thickness) of NiZAF induced by the rare earth ion Dy<sup>3+</sup>-doping. Motivated by our in-house laboratory measurements (SQUID and MOKE) and XMCD experiments using synchrotron x-rays, we performed soft x-ray resonant magnetic reflectivity (XRMR)<sup>5</sup> and related simulations to probe the magnetic depth profile. The magnetic asymmetry analysis for the Fe-L3 edge (Fig. 1a) using Dyna software shows nice agreement for a model considering an in-plane spiral-type spin structure with weak out-of-plane magnetization component, confirming the noncollinear (and noncoplanar) spin-configuration in the Dy-doped NiZAF. This spiral spin structure for the Fe-spins is sketched in Fig. 1b. We attribute the stabilization of such noncollinearity to the formation of a local strain field created by the Dy<sup>3+</sup> (evidenced by Dy-L3 EXAFS analysis) thereby involving local space-inversion symmetry breaking and emergence of asymmetric Dzyaloshinskii-Moriya interaction. This is supported by our first-principle DFT calculations.

The realization of noncollinear spin structure in the insulating spinel-ferrite opens further pathway to explore the possibility of chiral magnetic domain and topological spin textures (e. g., skyrmions) potential for the oxide-based spintronic applications.

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### REFERENCES

- [1]. A. Fert, N. Reyren and V. Cros, Nat. Rev. Mater. 2, 17031 (2017). [2]. S. K. Kim et al. Nat. Mater. 21, 24-34 (2022).  
 [3]. Y. Yafet and C. Kittel, Phys. Rev. 87, 290-294 (1952). [4]. S. Emori et al., Adv. Mater. 29, 1701130 (2017).  
 [5]. J.-M. Tonnerre et al., Eur. Phys. J. -Spec. Top. 208, 177-187 (2012)

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