Nonreciprocal Spin Dynamics in Artificial Chiral Magnets

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Magneto-chiral anisotropy, arising from time reversal asymmetry and spatial inversion asymmetry, leads to directional-dependent transport properties [1]. Chiral magnets are a class of particular materials, which possesses helical arrangement of magnetic moments, exhibiting pronounced nonreciprocal propagation in the presence of an external magnetic field. However, the intricate fabrication procedures and constrained temperature range for conventional chiral magnets limit their advancements in practical applications. In this study, we present artificial chiral magnets (ACMs) that demonstrate spontaneous magnetochiral anisotropy and significant nonreciprocal magnon transport without an external magnetic field [2]. These ACMs, designed as screw-like nickel tubes with a uniform 30 nm thickness, are fabricated using atomic layer deposition and two-photon lithography [3]. The magnetization inherits screw-like helical spin textures, giving rise to opposing toroidal moments [4]. Through the characterization of the nonreciprocal magnon spectrum via Brillouin light scattering spectroscopy, we reveal that the chiral parameter of the ACMs is three orders of magnitude stronger than those reported in conventional chiral magnets. The versatility and scalability of our 3D additive manufacturing technique offer significant potential for curvature-engineered ferromagnets enabling unidirectional GHz signal steering in all three directions on a chip at room temperature. This research is supported by the SNSF via grant number 197360.

1. G. L. J. A. Rikken, J. Fölling, and P. Wyder, *Electrical magnetochiral anisotropy*, Phys. Rev. Lett. 87, 236602 (2001)
2. M. Xu, A. J. M. Deenen, H. Guo, and D. Grundler, *Room temperature realization of artificial chiral magnets with reprogrammable magnon nonreciprocity at zero field*, arXiv: 2404.19153v2 (2024)
3. H. Guo, A. J. M. Deenen, M. Xu, M. Hamdi, and D. Grundler, *Realization and Control of Bulk and Surface Modes in 3D Nanomagnonic Networks by Additive Manufacturing of Ferromagnets*, Adv. Mater. 35, 2303292 (2023)
4. N. A. Spaldin, M. Fiebig, and M. Mostovoy, *The toroidal moment in condensed-matter physics and its relation to the magnetoelectric effect*, J. Phys. Cond. Mat. 20, 434203 (2008)

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