Imaging the Hamonic Generation of Magnons

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This work examines the mechanisms underlying the harmonic generation of magnons [1]. Harmonic generation is a nonlinear process that is well known in nonlinear optics, where a strong pump excitation frequency ω can generate tones at 2ω, 3ω, 4ω etc. I will describe our experiments imaging the harmonic generation of magnons in a $Ni_{81}Fe_{19}$/Pt microstrip using a scanning nitrogen-vacancy (NV) center microscope. We analyze these measurements in a nonlinear spin-wave framework that is directly analogous to harmonic generation in nonlinear optics. Within this framework, the harmonic response arises from nonlinear magnetization dynamics localized at strongly inhomogeneous textures, such as the sample edges and domain walls, that act as anharmonic confining potentials. This behavior is confirmed experimentally (Figure 1). We measure the expected nonlinear power-law scaling of amplitude, a systematic shift toward larger wavevector excitations at higher harmonic order, and a spin-selective response indicative of an increasingly chiral harmonic stray field. These results provide a microscopic understanding of magnonic harmonic generation and highlight its potential for engineering nonlinear functionality in magnonic systems.

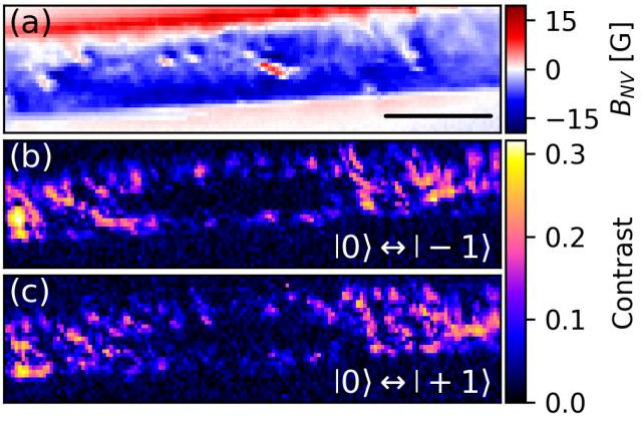

Figure 1. Results of a wide-field scanning NV center measurement. (a) Image of the magnetic field above the magnetic microstrip under a static magnetic field of 25 G. (b,c) Measurements of the amplitude of the third-harmonic signal using the NV center $|0\rangle \leftrightarrow |-1\rangle$ and the $|0\rangle \leftrightarrow |+1\rangle$ transitions, respectively. The scale bar in (a) is 5 μm and applies to all images.

[1] A. J. D'Addario, K. Hu, M. W. Olszewski, D. C. Ralph, M. E. Flatté, K. C. Nowack, and G. D. Fuchs, arXiv:2603.14082 (2026)

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