Nonlinear and Noreciprocal Generation of Spin Wave Harmonics in Thin Magnetic Films with Interfacial Dzyaloshinskii–Moriya Interactions

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We study the effect of the Dzyaloshinskii–Moriya Interaction (DMI) on the nonlinear creation of spin wave harmonics. We analyze the Landau-Lifshitz equations, numerically and analytically, for a narrow stripe with interfacial DMI. If the static field is perpendicular to the stripe, spin waves traveling in one direction along the long axis of the stripe can have harmonics that are more than 50 times larger than that for the waves moving oppositely. This can be understood as resulting from the nonlinear interfacial DMI torque terms in the Landau -Lifshitz equations as their amplitude is proportional to the magnitude of the propagation wavevector.

When the external field is parallel to the stripe, and with DMI present, both even and odd harmonics are generated; without DMI only odd harmonics appear. This potentially offers a new way to measure the DMI strength. Again, a simple perturbation scheme allows one to understand why the interfacial DMI case generates both even and odd harmonics, while the exchange-only case generates only odd harmonics.

In systems with larger nonlinearity, through an increased driving field or a different choice of driving frequency, frequency combs can appear, centered around each harmonic. The parameters used in the calculation are appropriate to create harmonics that can be measured with a network analyzer, a waveguide structure, and a spectrum analyzer or with Brillouin Light Scattering.[1]

References:

[1] Y. Khivintsev et al, Appl. Phys. Lett., 98, (2011) 042505