

Resonant dynamics of three-dimensional skyrmionic textures in thin film multilayers

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Skyrmions are topological magnetic solitons that exhibit a rich variety of dynamics, such as breathing and gyration, which can involve collective behavior in arrangements like skyrmion lattices. However, such localized excitations typically lie in the gap of the spin wave spectrum and do not couple to propagating modes. Here, we discuss micromagnetics simulations of the static and dynamic properties of the magnetization in thin-film multilayers of [Pt/FeCoB(1.2 nm)/AlOx]₂₀ [1]. As a function of applied field we identify distinct branches in the resonant response to microwave fields, which we label low-, intermediate-, and high-frequency modes (LFM, IFM, and HFM, respectively). Notably, the HFM (> 12 GHz) has not been reported previously and accompanies the skyrmion lattice phase, which involves the coherent precession of the skyrmion cores that results in the generation of 50–80 nm wavelength spin waves flowing into the uniformly magnetized background. The simulations also reveal a complex three-dimensional spin structure of the skyrmion cores, which plays a key role for spin wave generation. Such spin waves are also found to assist in the ordering of the skyrmion lattice.

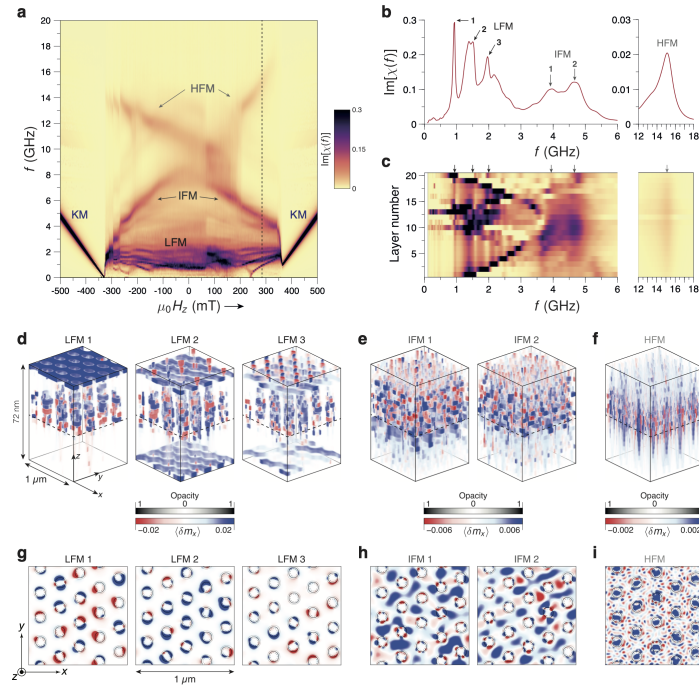


Figure 1: (a) FMR spectra simulated by calculating the frequency-dependent susceptibility of multilayer to uniform excitation fields. (b) Imaginary part of the magnetic susceptibility, showing three LFM, two IFM and one HFM excitation. (c) Thickness-resolved susceptibility. (d, e, f) Three-dimensional view of the magnetic response $\langle \delta m_x \rangle$ for (d) LFM, (e) IFM, and (f) HFM. (g, h, i) Two-dimensional view of the magnetic response $\langle \delta m_x \rangle$ in layer 10 of the modes in (d,e,f) for (g) LFM, (h) IFM, and (i) IFM.

References

[1] T. Srivastava *et al.*: Resonant dynamics of skyrmion lattices in thin film multilayers: Localised modes and spin wave emission. arXiv:2111.11797 [cond-mat.mes-hall].