Resonant dynamics of skyrmion lattices in thin film multilayers: Localised modes and spin wave emission

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The rich and diverse eigen-excitations of non-collinear magnetic textures in the GHz range offer a multitude of exploitable properties for magnonics [1,2]. Lately, the topologically non-trivial chiral magnetic textures called skyrmions have amassed huge interest owing to their particle-like nature and manoeuvrability [3]. While their dc current driven dynamics in thin films has been extensively studied, their microwave response remains largely unexplored owing to large damping coefficients

Here, we report the resonant dynamics of ultrathin film [Pt/CoFeB/AlOx]×20 multilayer hosting stable skyrmion lattices under ambient conditions, while exhibiting Gilbert damping α= 0.02. We identify distinct spin wave (SW) modes of skyrmion lattice using ferromagnetic resonance (FMR) and magnetic force microscopy experiments in conjunction with micromagnetic simulations.

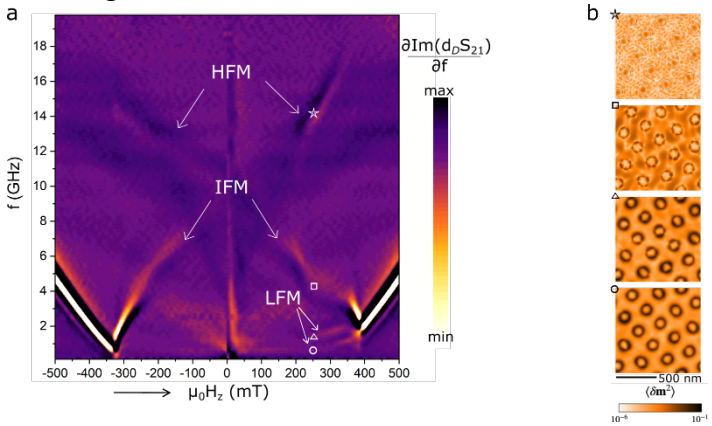

Figure 1: (a) Frequency-field dispersion measured by FMR over a frequency range of 0.1 to 20 GHz with applied out-of-plane field. (b) Simulations: Time averaged dynamic response of the norm of the transverse component in response to the in-plane excitation field at four different resonant frequencies marked by symbols on the resonance map in (a).

Two eigenmodes corresponding to azimuthal SWs localised to the skyrmion edges, are observed at low frequency (LFM, < 2 GHz), while the dynamics of the inter-skyrmion region result in an intermediate frequency mode (IFM, <8 GHz). A high frequency mode (HFM, >12 GHz) is also detected which is attributed to the in-phase precession of the magnetization inside the skyrmion cores, which possess a distinct three-dimensional structure due to the competition between all the existing magnetic interactions in these multilayers [4]. This precession is accompanied by the emission of SWs, with wavelengths in the range of 50 to 80 nm, into the uniformly magnetized background state. These SWs interfere with those generated at neighbouring skyrmion cores, yielding a collective dynamical state governed by the subtle interplay between the skyrmion diameter, the wavelength of the emitted SWs, and the skyrmion lattice periodicity.

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