Exploration of nonlinear hybrid magnonics:

Control of non-volatile magnonic memory in nonlinearly coupled system

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Harnessing nonlinear dynamics in hybrid magnonic systems offers a pathway towards novel device functionalities, including power-dependent mode evolution, bistability, and the suppression of hybridization gaps [1,2]. In particular, synthetic antiferromagnets (SAFs) have recently emerged as a versatile platform where magnon–magnon interactions can be driven beyond the linear regime [3,4]. Despite this progress, the nonlinear interplay between multiple magnon branches inherent to SAFs—namely acoustic and optic modes—has not yet been systematically explored and developed in application.

Here, we explore the nonlinear interaction in a magnon–magnon coupled hybrid system in a CoFeB/Ru/CoFeB synthetic antiferromagnet with antiferromagnetic interlayer exchange. By varying the external excitation power, we identify a pronounced power-induced transition between the predominant mode (acoustic or optic) in the propagation spectrum. We refer to this effect as 'mode hopping'. Near the critical magnetic field where the optic mode frequency approaches twice that of the acoustic mode, this mode hopping shows significant hysteresis (Fig.1) depending on the magnetic field sweep direction. This behavior is consistent with a three-magnon scattering mechanism. Building on this hysteretic behavior, we next realize a nonlinearly controllable, nanoscale mode selector in the GHz frequency range based on mode hopping. The change of the predominant magnon mode also has nonvolatility which is crucial for magnonic memory storage. Our results demonstrate that nonlinear coupling between acoustic and optic magnons in SAFs can be exploited as an active functionality, highlighting SAF-based structures as a promising route toward low-power, reconfigurable, non-volatile magnonic devices.

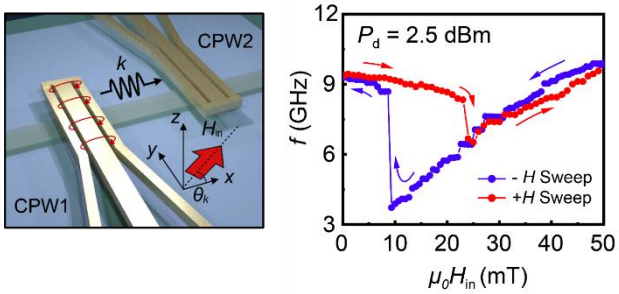

Fig. 1. (Left) Schematic illustration of experimental set-up which consists of 2 CPW antennas with SAF microstrip-line. (Right) The hysteresis of mode hopping with respect to external field-sweep direction at the power 2.5 dBm.

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