Nonlinear excitation of high-frequency short-wavelength spin waves within magnonic crystals

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The confined spin-wave modes show great potential for investigation of nonlinear effects. When combined with confined electromagnetic fields, they hold much promise for future advancements in quantum technology. Here we use a standard coplanar waveguide (CPW) to generated microwave magnetic field which pumps a spin-wave mode confined in the cavity of a magnonic crystal. The cavity is created by removing 3 holes from the square lattice of antidots based on a thin permalloy (Py) film saturated by the external magnetic field (see Fig. 1a). We find that the frequency of the fundamental cavity mode is equal to the ferromagnetic resonance frequency of the planar ferromagnetic film and overlaps with the magnonic band gap. When the threshold value is surpassed by the microwave magnetic amplitude, the fundamental mode yields multi-frequency harmonics in the magnonic crystal. Specifically, at an external static magnetic field of 0.5 T, the second and third harmonics generate at 48.6 and 72.9 GHz, respectively (Fig. 1b). These high-frequency harmonics may interact with the spin-wave bands of the magnonic crystal and generate propagating waves at 44 and 22 nm wavelengths (Fig. 1c). The effectiveness is influenced by the width of the CPW and its position relative to the cavity; however, it reaches saturation when the CPW covers the entire cavity. The non-linear excitation of high-frequency, short-wavelength spin waves demonstrated in the magnonic crystal cavity holds promise for future advancements in high-frequency magnonics.

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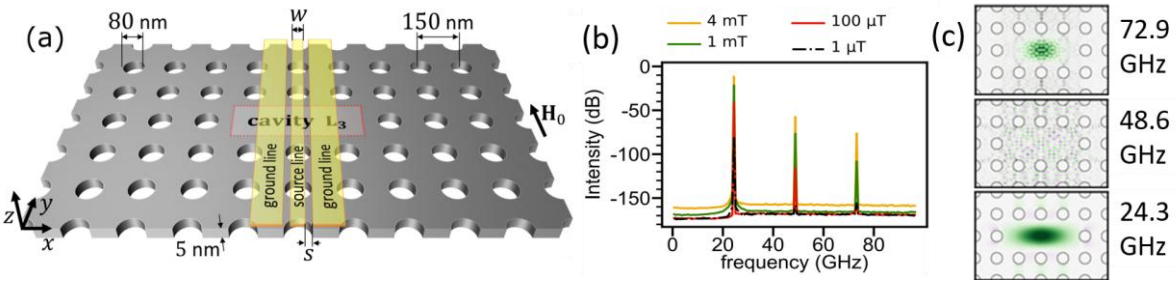

Fig. (a) Schematic of structure: an antidot lattice with an L3 cavity cantered at $x = 0$ and $y = 0$. Magnonic crystal is made of a 5 nm thick Py-film with magnetization saturated by the magnetic field H_0, the diameter of the antidots is 80 nm and the lattice constant is 150 nm. A CPW antenna is placed just above the film. (b) Spin-wave spectra ($\propto m_z^2$) excited with CPW of $w = 400$ nm and located at the centre of cavity L3 at the frequency 24.3 GHz and the different amplitudes. (c) Spatial distributions of amplitudes of mz of the SW modes corresponding to the fundamental cavity mode (24.3 GHz), and its second (48.6 GHz), and third (72.9 GHz) harmonics (amplitude of microwave field 4 mT).