Spin waves in YIG-based metastructures

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KEY WORDS: Spin waves, YIG films, subwavelength periodic structures

Periodic magnetic structures – magnonic crystals – allow to control the spin wave (SW) spectrum that can be used for microwave signal processing. The main feature of SW's propagation in magnonic crystals (MC) is formation of the forbidden band gaps in their spectra which appear at Bragg resonance frequencies f_B corresponding to the condition $\lambda(f_B) = 2\Lambda/n$, where Λ is the period of the structure, λ is the SW's wavelength, $n=1, 2,..$ In the case when subwavelength condition $\lambda \gg \Lambda$ is fulfilled the MC can be considered as a metastructure. So far the case when the subwavelength condition $\lambda \gg \Lambda$ is fulfilled was poorly studied and only theoretically[1]. In this work we present results of investigations of SW's propagation in magnetic metastructures based on micrometer thick yttrium iron garnet (YIG) films.

Most attention paid to the experimental results on the magnetostatic surface wave (MSSW) propagation in YIG films with "leaky" and "resonant" metasurfaces (MS). The first type of MS represented itself the grooves with subwavelength period etched in the YIG film surface and the second one – the plane YIG film with the subwavelength periodic array of micron-sized magnetic stripes placed on its surface. Such structures demonstrated effects of MSSW filtration and formation of anomalous regions in its dispersion.

In the case of the YIG film with "leaky" MS such effects were explained as the resonant interaction of the MSSW with the leaky exchange modes that appeared due to demagnetization fields created by the surface periodic structure. The filtering effects and dispersion of MSSW in the film with 1D- "leaky" MS was studied as a function of the angle between the directions of the magnetic field and the grooves. It was shown that anomalous regions are formed in the MSSW dispersion and their number and width are minimal for the bias field applied along the grooves and maximal for the fields perpendicular to grooves axis (Laue geometry).

MSSW propagation in YIG film with "resonant MS" accompanied by the appearance of resonance features in the transmission characteristics and dispersions and could be considered as a result of the resonant interaction of two magnetostatic SWs propagating in two plane YIG films. One of them is the actual thick YIG film and the other one is the effective thin YIG film that is equivalent to the YIG microstripe array. An influence of SW parametric instability (both first and second order) on SW propagation in YIG-based metastructures is also discussed.

This work was supported by RFBR (Grant Nos. 16-57-00153, 16-02-01073, 17-07-01452) and Belarusian Republican Foundation for Fundamental Research (Grant No. F16R-086).

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