Control of the phase of spin wave reflected from a subwavelength Gires-Tournois interferometer

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The usage of metasurfaces consisted of nano-resonators was an innovatory concept in photonics and optics which led to designing of multiple devices of performance exceeding classical applications. It becomes possible with metasurfaces to change the properties of a wave at subwavelength distances. However, this concept has not been extensively studied in magnonics even though control of the phase of the spin waves (SWs) at ultra-short distances is of great importance for application.

We numerically study the influence of a sub-wavelength stripe placed over a ferromagnetic film made of permalloy on the phase of reflected SWs [1]. We consider resonators made of two types of materials, permalloy and a material with saturation magnetization lower than permalloy. Utilizing frequency-domain finite element method calculations we showed that by changing the geometry properties of the stripe and the layer we can obtain a full angle phase change of the reflected wave. Additionally, for certain geometries, the resonance behaviour can be seen in the bilayer part of the system consisted of the layer and the stripe. Those resonances are present when the Fabry-Pérot condition is met and then the phase of reflected SW changes abruptly with a small alteration of geometry of the system. We have shown that the occurrence of the resonances can be modified by changing thicknesses of the magnetic elements. To explain the behaviour of the SWs in the system, the two-mode model analysis was developed. This analysis shows that the symmetric fast mode of the bilayer gives an input to a steady increase of the phase. On the other hand, the antisymmetric slow mode is responsible for the resonances in the system, as its input is significant only when the Fabry-Pérot condition is fulfilled.

Summarizing, our system can be regarded as a realization of the magnonic Gires-Tournois interferometer of subwavelength width suitable for the control the phase of the SW. This system may be used as a building block in more complicated magnonic devices as phase shifters or detectors of magnetic particles.

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References:

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