Self-imaging of spin waves in thin, multimode ferromagnetic waveguides

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The Talbot effect, called also a self-imaging, has been known in linear optics since the 19th century and has found various technological applications. Self-imaging is also a property of multimode waveguides, that can be used to create advanced logic circuits also in magnonics. After our successful demonstration of this effect for spin waves using micromagnetic simulations [1] in infinitely wide systems (with periodic boundary conditions), it is time for real-size systems that can be used in future magnonic devices. At this conference, I would like to present a family of out-of-plane magnetized ferromagnetic waveguides, in which, as a result of combining Talbot effect and multimode interference, regular self-imaging of patterns characteristic for the near diffraction field occurs and they are created at equal distances away from a number of sources (single-mode waveguides). Using micromagnetic simulations I demonstrate systems with various parameters such as: number of sources, width of the system and distance between the sources (which in this case is an analog of a diffraction grating constant) to analyze and compare the obtained interference fields in terms of possible application. In many cases, interesting effects can be observed and, especially in the near diffraction field, patterns similar to the theoretical images known as „Talbot carpets", which is particularly interesting due to the possibility of applying this effect in systems with higher damping. The object of my interest are also analogous in-plane magnetized systems, with additional effects due to anisotropy. The self-images created in the waveguides were analyzed in systems with a low Gilbert damping constant, and it seems that this effect can be used experimentally with great efficiency, e.g. in yttrium iron garnet materials.
From the conclusions of the described research, it can be distinguished, among others, that the self-imaging effect for spin waves occurs in systems of finite dimensions, multimode interference transfers and duplicates the near diffraction field to further, repeatable distances from the sources and it is possible to control this effect by selecting an appropriate geometry and parameters. It gives a lot of application possibilities, as well as ways of manipulating and adapting the effect to specific needs. The obtained results help to better understand spin-wave interference and diffraction processes due to the use of a number of coherent spin-wave sources and I believe my findings open an avenue to practical application of the Talbot effect in future magnonic devices.

References:

[1] M. Gołębiewski et al., Phys. Rev. B 102, 134402 (2020)