



HAL
open science

Shaping non-reciprocal spin wave beams in thin magnetic films

V Vlaminck

► **To cite this version:**

V Vlaminck. Shaping non-reciprocal spin wave beams in thin magnetic films. 1st Workshop SWING, <https://swing-workshop1.sciencesconf.org/>, May 2024, Strasbourg, France. hal-04726615

HAL Id: hal-04726615

<https://hal.science/hal-04726615v1>

Submitted on 8 Oct 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Shaping non-reciprocal spin wave beams in thin magnetic films

V. Vlaminck^{1,2}

¹ IMT Atlantique, Institut Mines Telecom Atlantique, Microwave Dpt., CS 83818, 29238 Brest, France

² Lab-STICC (UMR 6285), CNRS, Technopole Brest-Iroise, CS 83818, 29238 Brest Cedex 3, France

corresponding author: vincent.vlaminck@imt-atlantique.fr

Abstract:

Magnonic devices, which take advantage of the versatility of spin waves, are anticipated to be a propitious alternative for efficient signal processing. Spin waves constitute the building blocks of novel wave computing methods such as spectral analysis [1], and neuromorphic computing [2], which are all interference based techniques. Recently, basics concepts of optics applied to spin waves demonstrated the possibility to shape and stir spin wave beams, suggesting prominent performance in particular tasks such as image processing and speech recognition [3]. Along these ideas, we demonstrated that the beamforming in ferromagnetic thin films follows directly the near-field interference pattern of the excitation geometry [4-7].

Here, we present several approaches that allows exciting non-reciprocal spin wave beams in thin magnetic films such as curvilinear antennas, grating of nanomagnets, and sharp constrictions. We first present a near-field diffraction model that benchmarks spin wave beamforming in thin films for any geometry. Then, we experimentally test our predictions using both spin wave spectroscopy and micro-focused Brillouin light spectroscopy to map diffraction patterns in the 2D plane. We will show in particular how a sharp constriction in an antenna can directly excite non-reciprocal caustic beams in an extended film when the suitable conditions of field and frequency meets an inflection point in the dispersion relation. These findings have important implications for the development of switchable spin wave splitters, passive spin-wave frequency-division demultiplexers, and magnonic interferometry.

This work was supported by the French ANR project MagFunc, the Département du Finistère through the project “SOSMAG”, and the Transatlantic Research Partnership, a program of FACE Foundation and the French Embassy.

References

1. Papp, A. and Porod, W. and Csurgay, A. I. and Csaba, G. “Nanoscale spectrum analyzer based on spin-wave interference”, *Scientific Reports* **7**, 9245, (2017).
2. Papp, A. and Porod, W. and Csaba, G. “Nanoscale neural network using non-linear spin-wave interference”, *Nature Communications* **12**, 6422, (2021).
3. Albisetti, E and Tacchi, S. and Silvani, R. and Scaramuzzi, G. and Finizio, S. and Wintz, S. and Rinaldi, C. and Cantoni, M. and Raabe, J. and Carlotti, G. and Bertacco, R. and Riedo, E. and Petti, D., “Optically inspired nanomagnonics with nonreciprocal spin waves in synthetic antiferromagnets”, *Advanced Materials* **32**, 1906439, (2020).
4. Loayza, N. and Jungfleisch, M. B. and Hoffmann, A. and Bailleul, M. and Vlaminck, V., “Fresnel diffraction of spin waves”, *Physical Review B* **98**, 144430, (2018).

5. Vlaminck, V. and Temdie, L. and Castel, V. and Jungfleisch, M. B. and Stoeffler, D. and Henry, Y. and Bailleul, M., “Spin wave diffraction model for perpendicularly magnetized films”, *Journal of Applied Physics* **133**, 053903, (2023).
6. Temdie, L. and Castel, V. and Dubs, C. and Pradhan, G. and Solano, J. and Majjad, H. and Bernard, R. and Henry, Y. and Bailleul, M. and Vlaminck, V., “High wave vector non-reciprocal spin wave beams”, *AIP Advances*, **13**, 2, 025207, (2023).
7. L. Temdie, V. Castel, M. Jungfleisch, R. Bernard, H. Majjad, D. Stoeffler, Y. Henry, M. Bailleul, and V. Vlaminck. “Probing spin wave diffraction patterns of curved antennas”, *Phys. Rev. Appl.* **21**, 014032 (2024).