Magnon beamforming at the nanoscale

The emerging field of magnonics focuses on the transport and processing of information by elementary magnetic excitations called spin waves (or their quanta magnons) [1]. A Travelling spin wave carries angular momentum without a net motion of charges; therefore, it appears as a potential building block for low-power data processing and computing [2]. Furthermore, magnons display unique properties of anisotropy, non-linearity, and non-reciprocity that are finely tunable in a broad range of the microwave spectrum. The peculiar wave nature of magnon constitutes of formidable ground for novel wave computing methods, such as spin wave logic, holographic memory, and neuromorphic computing, all of which are essentially interference based methods.

Along this global effort to explore the interferometric potential of magnons, we offer at IMT Atlantique in Brest (<https://www.imt-atlantique.fr/en/research-innovation/phd>) a PhD position starting in the fall 2024 to study the shaping and the manipulation of spin wave beams at the nanoscale. Recent advances inspired from the concepts of optics demonstrated the focusing or diffracting of spin wave beams in continuous film with properly designed microwave antennas [3,4]. In parallel, unidirectional transmission of micron-size spin waves beam was achieved very recently using the chiral coupling between the uniform resonance of NiFe nanowires and exchange spin waves in a thin YIG film [5]. In this project, we aim at combining both ideas, and explore configurations of magnetic nanostructures coupled to a continuous thin film that can create interference pattern readily adjustable.

The first part of the work entail designs and simulations aiming at identifying the most prominent assemblies of nanomagnets. The second part of the work will consist in nano-fabrication of devices and their measurement to demonstrate the feasibility of a magnon interferometer. This project is funded by the collaborative PEPR SPIN program within the project SWING (“*Spin waves for advanced signal processing*”), which will involve frequent collaborations with major spintronic labs in France within a large collaborative program entitled PEPR SPIN.

We are looking for candidates with sharp written and oral communication skills that are used to carrying out technical tasks autonomously. Candidates should email their application directly to Dr. Vincent Vlaminck at vincent.vlaminck@imt-atlantique.fr, before July 27th 2024.

[1] A. Barman et al., “*The 2021 Magnonics Roadmap*” J. Phys.: Condens. Matter **33**, 413001 (2021).

[2] A. V. Chumak et al., “*Advances in Magnetics Roadmap on Spin-Wave Computing*”, IEEE TRANSACTIONS ON MAGNETICS **58**, 6(2022).

[3] N. Loayza, M. B. Jungfleisch, A. Hoffmann, M. Bailleul, and V. Vlaminck, “*Fresnel diffraction of spin waves*”, Phys. Rev. B **98**, 144430 (2018).

[4] L Temdie, V Castel, V Vlaminck, MB Jungfleisch, R Bernard, H Majjad, ..., “*Probing Spin Wave Diffraction Patterns of Curved Antennas*”, Phys. Rev. Appl. **21** (1), 014032.

[4] L. Temdie, V. Castel, C. Dubs, G. Pradan, J. Solano, H. Majjad, Y. Henry, M. Bailleul, V. Vlaminck, “*High Wave Vector Non-reciprocal spin Wave Beams*”, AIP Advances **13**, 025207 (2023)