Master in Photonics – "PHOTONICS BCN"
Master ERASMUS Mundus "EuroPhotonics"

MASTER THESIS PROPOSAL

Starting full time from April 2025
Presentation at the end of July or beginning of September 2025

Laboratory: Applied Physics
Institution: Universitat de Barcelona
City, Country: Barcelona, Spain

Title of the master thesis: Design and implementation of a vectorial Magneto-Optic Kerr Effect microscope

Name of the master thesis supervisor and co-supervisor:
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Keywords:

Summary of the subject (maximum 1 page):

Ferromagnetic materials are used in many different applications, from sensors to information storage. These materials exhibit a net magnetic moment in the absence of any applied field, and their direction can be switched by an external field. The process of switching, which is key to determining the magnetic memory of the material, occurs by forming domains (regions) of different magnetization. By knowing the domain structure and its motion we can study the dynamics of the switching process, which usually occurs by magnetization jumps, giving rise to the so-called Barkhausen noise.

Several techniques have been developed to image and characterize magnetic domains. A widely used strategy is Magnetic Force Microscopy. Based on point-by-point sample interrogation, it allows a high spatial resolution (nm scale) but at a speed not suitable for studying magnetization dynamics. Alternatively, optical methods such as the Magneto-optical Kerr effect (MOKE), can be used for fast and sub-micrometric magnetic domain imaging. Typically, MOKE systems use an optical microscope to measure changes in light polarization of the light reflected on the sample surface, as shown in Fig 1. Thus, diffraction-limited imaging is possible only limited by the camera frame rate. Unfortunately, MOKE microscopy requires erasing the magnetic state (information) to produce a background image. As a result, the domain configuration must be recreated frequently, something incompatible with certain studies, including paleomagnetism, where domains reveal the earth's magnetic field at the time of the mineral formation.

In this TFM we propose a new MOKE microscopy system that obviates the need for initially erasing the magnetic state of the sample. Our idea is to use structured illumination generated from a

digital micromirror device (DMD). In more detail, we plan to use the DMD to translate a light spot at different locations at the back pupil of the objective lens, resulting in changes in the plane of incidence of the light. Opposite incidences produce an inversion of contrast and thus, capturing a pair of such incidences will allow retrieving the magnetic states without the need for erasing the initial magnetic information. Moreover, since MOKE is only sensitive to the magnetization projection to the incident plane, the DMD will allow a vectorial resolution of the magnetization. We believe that the proposed structured illumination MOKE microscope presents a promising advancement in the study of magnetic domains and their dynamics with a temporal detail not currently possible.

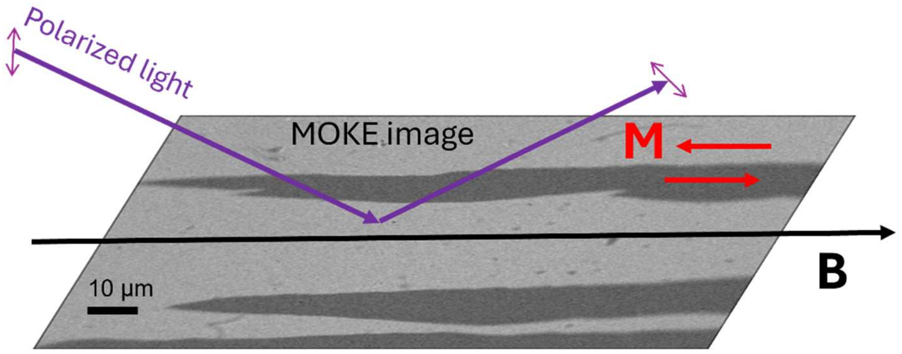

Fig 1. MOKE experimental setup. Contrast is given by the magnetization projection to the plane of incidence of the polarized light.

Objectives:
To fulfill the main objective of this master thesis, we have identified the following specific objectives, which will occur sequentially through a 3-month period, as detailed next.:

- Implement a digital micromirror device for generating light patterns at the back pupil of the MOKE microscope objective.
- Characterize the illumination uniformity at the sample's plane.
- Generate an initial estimate of the magnetic domain distribution by subtracting two images generated by two different light patterns.
- Writing of the thesis.

Additional information (if needed):
Possibility to receive a scholarship.
* Required skills: the candidate is expected to show an interest in multidisciplinary subjects, and basic programming in Python, MATLAB or LabView.