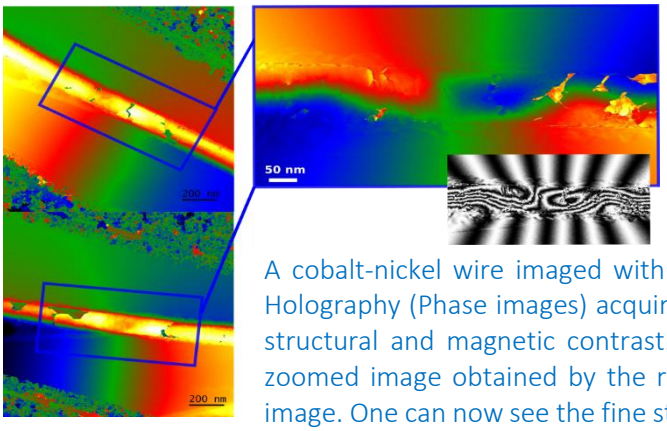
Multi-platform Image processing for Quantitative Magnetic Imaging

Context

Nanoscale characterization in the direct space (*i.e.*, imaging) is not only an observation at the nanometer scale, but allows a mapping of physical and functional properties. As regards magnetic imaging, several cutting-edge methods are used in SPINTEC to obtain quantitative magnetic information in objects relevant for future devices (domain walls in nanowires, skyrmions in patterned media, nano-magnets for non-volatile memories). Two prominent techniques are Electron Holography and X-ray Magnetic Dichroism. Both require to acquire multiple images with variations in the sample orientation or the incoming beam, and then to recombine them into a final image revealing the magnetic information. The ultimate spatial resolution and physical sensitivity can only be achieved through advanced sub-pixel realignment, to avoid artifact and obtain a reliable quantification. In addition, the emergence of *in situ* methods enable to quickly change the magnetic state, resulting in a large number of images to process in a careful way, up to video mode. The aim of this internship is to develop a robust and multi-platform flow for image realignment, resulting in a Python library and user-friendly interface. This platform will be implemented both on desktop and directly on microscopes, to provide a live processing to assist the experimentalists during acquisition.



A cobalt-nickel wire imaged with Electron Holography. Left : two acquisitions with Electron Holography (Phase images) acquired before and after flipping the sample by 180° top to split structural and magnetic contrast. The color codes the phase shift of electron waves. Top: zoomed image obtained by the registered subtraction of the two blue areas in the original image. One can now see the fine structure of the magnetic domain wall that can be highlighted showing only iso-phase variations (B&W image in the inset)

Work program & Skills acquired during internship

The internship will be devoted to experimental image processing using a Python ecosystem developed in the electron microscopy platform. Various tasks will be conducted:

- **hdf5** harmonisation (automatic generation, reading & sorting) of various magnetic images
- **Image registration** procedures in multiple steps (automatic & manual steps)
- Open access display via **Jupyther noetbook** of experimental results
- Implementation (translation or adaptation) of magnetic imaging libraries.

The main activity will then be dedicated to physical studies using **correlative microsopies** (association of various techniques on the same object) by taking part to experimental acquisition of data (either in front of or remotely) of TEM (Electron holography) and STXM (Ptychography). A PhD extension would extend to linking quantitatively experimental images and the output of micromagnetic simulations.

The candidate will gain various research skills such as : image processing, **electron microscopy**, **transmission x-ray microscopy**, team work, physic modeling, **micromagnetism**, spintronic, advance python programming

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Requested background: **Advanced python skills** - Master 2 in nanophysics/solid state physics/digital processing
Duration: 6 months
Start period: Feb/ March 2023
Possibility of PhD thesis : YES
Proposal number : do not fill in