# PhD project

## Interplay between strain and magnetism at the nanoscale: 3D imaging with coherent X-ray beams

Physical properties of materials depend not only on their intrinsic properties, but also on their microstructure. Magnetic properties are no exception. For instance, dislocation cores in NiO have been found ferromagnetic while the rest of the crystal in antiferromagnetic [1]. Similarly, elastic strain can modify the magnetic order [2]. The purpose of the project is to explore experimentally the microscopic mechanisms of these phenomena. A particular focus will be put on microcrystals grown by solid-state dewetting, such as Ni, Co [3] and FeRh [4] (Figure 1). We will use synchrotron radiation, and in particular techniques based on X-ray coherence [5], to image in 3D and with nanoscale resolution the lattice strain [6,7] (Figure 2) and the magnetic texture [8] (Figure 3) in crystals hosting magnetic order. The characterisation in 3D of the crystal microstructure and of the magnetic texture will allow correlating them, to better understand how they interact.
The PhD project will tackle all steps of the investigation: conception, growth and characterisation of samples, synchrotron measurements, data analysis and interpretation of the results. The work will be done in close collaboration with researchers from SIMaP, Institut Néel and ESRF, and possibly other partners.

**References**


[1] Sugiyama *et al.*, Ferromagnetic dislocations in antiferromagnetic NiO. Nature Nanotech **8**, 266–270 (2013). https://doi.org/10.1038/nnano.2013.45
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[4] Motyčková *et al.*, Preserving Metamagnetism in Self-Assembled FeRh Nanomagnets, ACS Appl. Mater. Interfaces 2023, 15, 8653−8665. https://doi.org/10.1021/acsami.2c20107
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[7] Comby-Dassonneville *et al*, Combining nanoindentation and Bragg coherent diffraction imaging to investigate small-scale plasticity, Materialia **39**, 102376 (2025). https://doi.org/10.1016/j.mtla.2025.102376
[8] Di Pietro Martinez *et al.*, Three-dimensional tomographic imaging of the magnetization vector field using Fourier transform holography, Phys. Rev. B **107**, 094425 (2023). https://doi.org/10.1103/PhysRevB.107.094425


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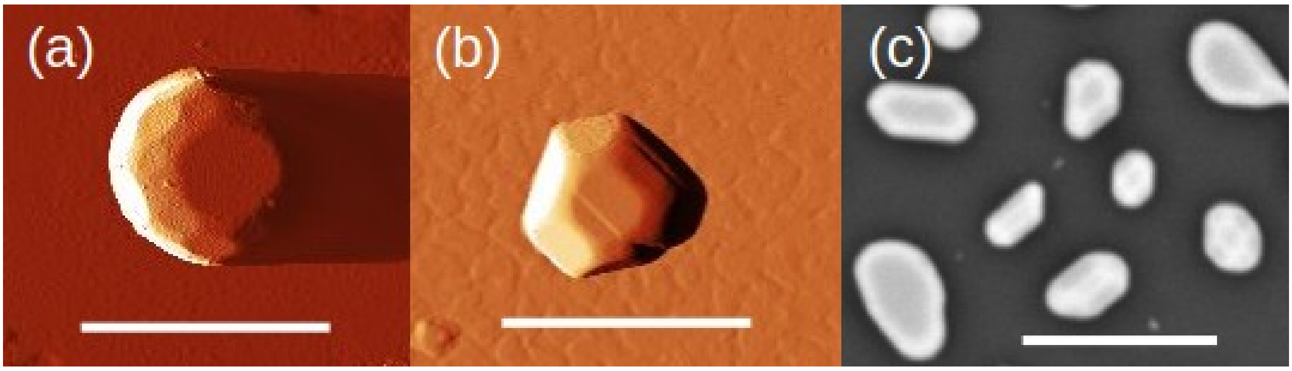

*Figure 1: Crystals obtained by solid-state dewetting. (a) Ni (b) Co (c) FeRh. A stacking fault is visible on the top facet of the Co crystal. The Ni and Co crystals were prepared in our lab [3]; the FeRh crystal is taken from [4]. Scale bars: 1 µm (a & b), 0.5 µm (c).*

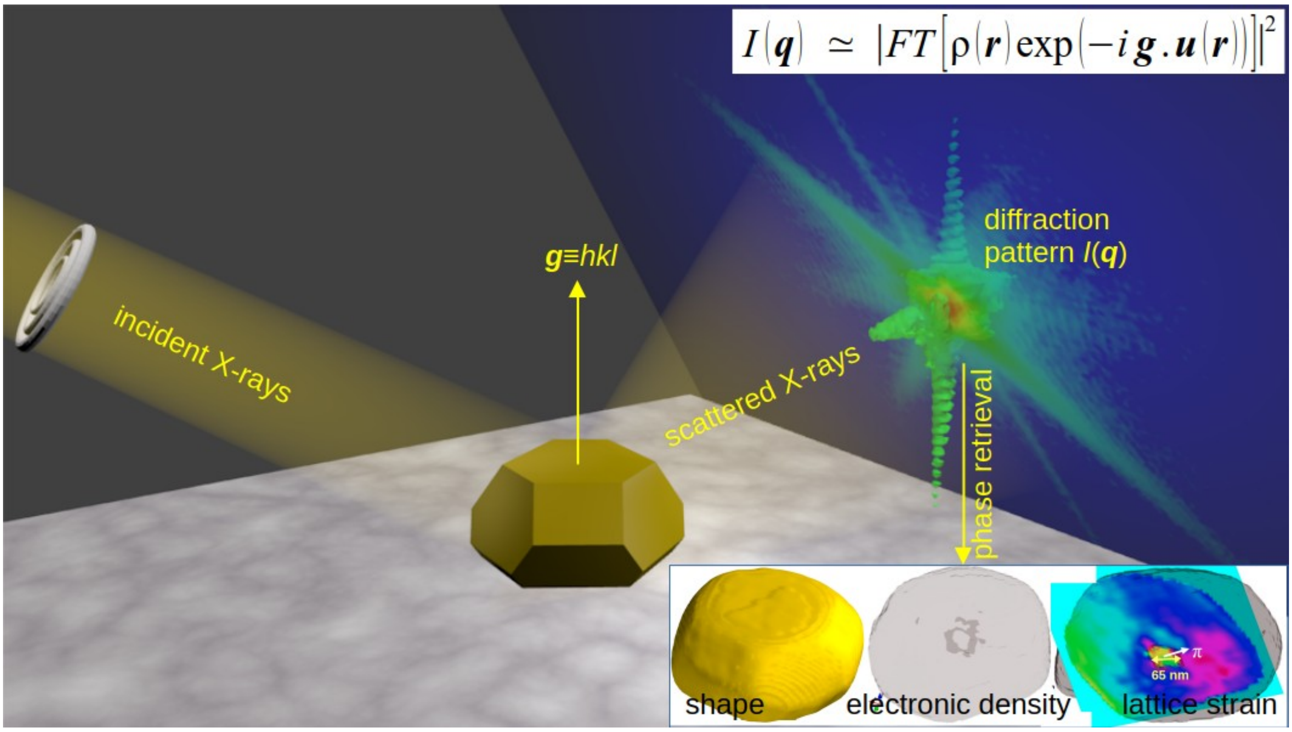

*Figure 2: Principle of Bragg Coherent Diffractive Imaging, adapted from [6&7].*

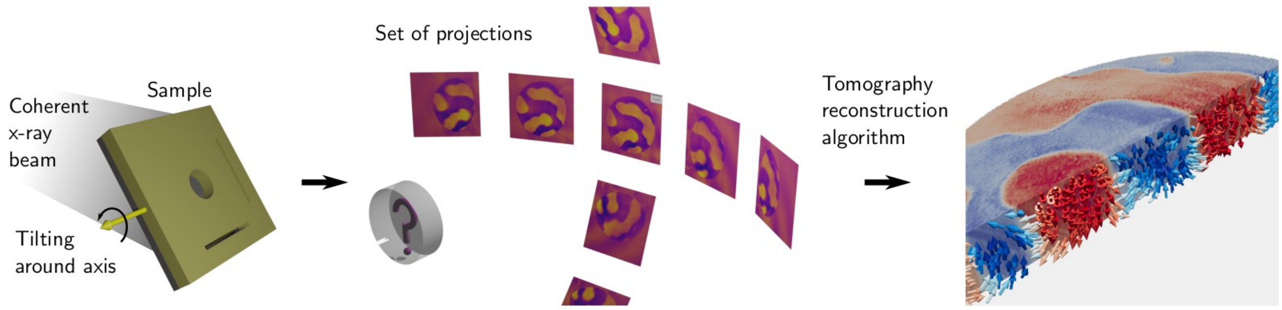

*Figure 3: Vectorial magnetic nanotomography based on Fourier-transform holography, adapted from [8].*