NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2019-2020

Skyrmions around room temperature in ferromagnetic/rare earth nanostructures

General Scope:

Magnetic skyrmions are chiral nanoscale textures **[1]** that show potential future device applications in the transportation and storage of information. On a fundamental level, skyrmions are model systems for topologically protected spin textures, emphasizing the role of topology in the classification of complex states of condensed matter. At the forefront of this research field is the development of transition-metal-based magnetic multilayer structures that support skyrmionic states around room temperature and allow for the precise control of skyrmions by applied currents and external fields. Recent experiments at the Sextants beamline (SOLEIL synchrotron) reveal the generation of skyrmions in Fe/Gd multilayers, by exploiting Fourier Transform Holography methods. This work builds on previously published work on Fe/Gd systems **[2,3]**. Our holography results (at **T**=320K) are summarized in figure 1(left) and figure 1(right**)** above. The left panel (1) shows the holography images (as developed in **[4]**) for magnetic fields **H** applied parallel to the X-ray beam and the right for magnetic fields applied antiparallel (**H** systematically perpendicular to the film).

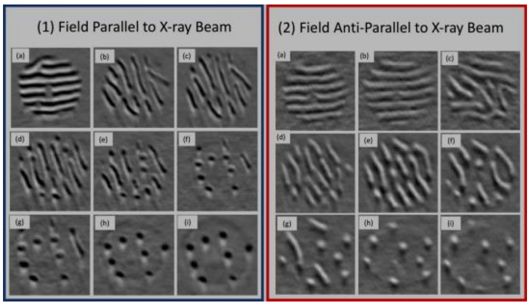

Figure 1*. Holography images of the magnetic domain formation magnetic fields applied parallel (left 1) and antiparallel (right 2) to the X-ray beam. Skyrmion like structures are observed in figures (g-h-i) with opposite dominant polarization for Fe/Gd multilayers.* The diameter circles is 2μm.

Skyrmion-like magnetic textures (diame ter~120nm) are formed (figs f-i) and their polarization can be controlled the direction of the magnetic fields (compare fig.1i to fig.2i). **The aim of this is project is to tune skyrmions in ferromagnetic/rare earth devices by varying the temperature T and the magnetic field H for specific multilayers.**

Research topic and facilities available:

At the Institute Neel, the candidate will explore the existence of skyrmions in ferromagnetic/rare earth multilayers by varying the nature (Gd,Tb,Fe,Co) as well as the thicknesses of layers. In particular, intensive extraordinary hall effects measurements will be tested in the [3-**700**]K and [0-8]Tesla ranges, for planar and perpendicular magnetic fields.

Bibliography: ***[1]*** *T. H. R. Skyrme, Nuclear Phys.* ***31****, 556 (1962).* ***[2]*** *J.C.T. Lee et al., Appl. Phys. Lett.* ***109*** *022402 (2016) ; S.A. Montoya et al. Phys. Rev. B* ***95*** *024415 (2017) ; S.A. Montoya et al. Phys. Rev. B* ***95*** *224405 (2017)* ***[3]*** *M. Guizar-Sicairos et al., Optics Express* ***15****, 17592 (2007).* ***[4]*** *T.A. Duckworth et al Opt. Express* ***19****, 16223 (2011).*

Possible collaboration and networking:

The student will be working within the Surface Interface Nanostructure (SIN) team of the Néel Institute. He/she will use different equipment's available at the laboratory (sputtering, X-Ray, Hall effects, resistance and magnetizations, nanofabrication). In collaboration with "Epitaxie couches minces", "Ingénierie Expérimentales", "Nanofab", and "X'Press" technological groups, as well as Spintec (UMR 8191, Grenoble)

Possible extension as a PhD: Yes

Required skills: Background in condensed matter physics (interests in the field of spintronic).

Starting date: March/April 2020

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