MA 43: Magnetic Imaging Techniques II

Time: Thursday 15:00–16:45 Location: HSZ 401

MA 43.1 Thu 15:00 HSZ 401

Three-dimensional tomographic imaging of the magneti- zation vector field using Fourier transform holography — •Marisel Di Pietro Martínez[1,2], Alexis Wartelle[1,3], Carlos Herrero Martínez[1], Farid Fettar[4], Jean-François Motte[4], Claire Donnelly[2], Luke Turnbull[5], Feodor Ogrin[5], Gerrit van der Laan[6], Horia Popescu[7], Nicolas Jaouen[7], Flora Yakhou-Harris[3], and Guillaume Beutier[1] — [1]UGA, CNRS, G-INP, SIMaP, Grenoble, France — [2]MPI-CPfS, Dresden, German — [3]ESRF, Grenoble, France — [4]UGA, CNRS, G-INP, Institut Néel, Grenoble, France — [5]School of Phys. and Engineering, University of Exeter, Exeter, UK — [6]Diamond Light Source, Didcot OX11 0DE, UK — [7]Synchrotron SOLEIL, Gif-sur-Yvette, France

Three-dimensional magnetic textures have recently attracted increasing interest both from a fundamental and a technological point of view. This emergent field of research comes with the need of new characterization techniques, specifically tomographic imaging. Here, we present a new tomographic technique based on Fourier transform holography, a lensless imaging technique that uses a known reference in the sample to retrieve the object of interest from its diffraction pattern in one single step of calculation. We obtain a 3D vectorial image of a 850nm-thick extended Fe/Gd multilayer in a 5000nm-diameter field of view with a resolution of 100nm, that reveals worm-like domains with magnetization pointing mostly out of plane near the surface of the sample but that falls in-plane near the substrate. As an outlook, this technique will enable a 3D study on the response to an external magnetic field.

MA 43.2 Thu 15:15 HSZ 401

Soft X-ray ptychography of micrometer thick samples — •Jeffrey N. Neethirajan[1], Benedikt Daurer[2], Ales Hrabec[3,4], Majid Kazemian[2], Marisel Di Pietro Martínez[1], Burkhard Kaulich[2], and Claire Donnelly[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Diamond Light Source, Harwell Science and Innovation Campus, Didcot, United Kingdom — [3]Laboratory for Mesoscopic Systems, Department of Materials, ETH Zurich, Zurich, Switzerland — [4]Laboratory for Multiscale Materials Experiments, Paul Scherrer Institute, Switzerland

Magnetism at the nanoscale offers a playground to study topology in real space. Although topological spin textures have so far been mainly studied in 2D, there is a growing interest in 3D topological spin textures. Recently, 3D imaging of extended systems with hard X-rays has revealed topological singularities called Bloch points and spin structures called vortex rings with nanoscale spatial resolution. However, the imaging of extended systems with hard X-rays is limited by the weak XMCD signals observed in this regime and restricted currently to a few rare-earths. In contrast, soft X-rays offer a stronger XMCD signal but limited to imaging samples that are 200-300 nm thick. Here we demonstrate the imaging of micrometer thick samples using soft X-ray ptychography - accessing a thickness regime previously impractical with conventional soft X-ray imaging techniques. This result is a step forward in realizing 3D imaging of extended systems with soft X-rays which offers a strong XMCD signal and the possibility to image exotic systems hosting topological textures.

MA 43.3 Thu 15:30 HSZ 401

Soft X-ray Ptychography of Bismuth Ferrite Nanoplates — •Tim A. Butcher[1], Manuel Langer[1], Simone Finizio[1], Lars Heller[1], Mirko Holler[1], Michal Jambor[2], Elisabeth Müller[3], Ashna Bajpai[4,5], Carlos A. F. Vaz[1], Armin Kleibert[1], and Jörg Raabe[1] — [1]Swiss Light Source, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland — [2]Institute of Physics of Materials, Czech Academy of Sciences, Žižkova 22, 61600 Brno, Czech Republic — [3]Electron Microscopy Facility, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland — [4]Department of Physics, Indian Institute of Science Education and Research, Pune 411008, India — [5]Centre for Energy Science, Indian Institute of Science Education and Research, Pune 411008, India

Soft x-ray ptychography is a scanning coherent diffractive imaging technique with spatial resolutions in the order of 10 nm, which relies on collecting diffraction patterns from overlapping illumination spots of the sample. The magnetic and ferroelectric structure of multiferroic bismuth ferrite nanoplates was studied with a new soft x-ray ptychography endstation at the Swiss Light Source. In particular, we demonstrate that the technique is able to resolve the antiferromagnetic spin cycloid and can yield the chirality in bismuth ferrite.

MA 43.4 Thu 15:45 HSZ 401

Direct imaging of nanoscale field-driven domain wall oscillations in Landau structures — •Balram Singh[1], Rachappa Ravishankar[1], Jorge A. Otálora[2], Ivan Soldatov[1], Rudolf Schäfer[1], Daniil Karnaushenko[3], Volker Neu[1], and Oliver G. Schmidt[3] — [1]Institute for Integrative Nanosciences, Leibniz IFW Dresden, 01069 Dresden, Germany — [2]Departamento de Física, Universidad Católica del Norte, Avenida Angamos 0610, Casilla 1280, Antofagasta, Chile — [3]Center for Materials, Architectures and Integration of Nanomembranes (MAIN), Chemnitz University of Technology, 09126 Chemnitz, Germany.

Linear oscillatory motion of domain walls (DWs) in the kHz and MHz regime is crucial when realizing precise magnetic field sensors such as giant magnetoimpedance devices. Here, we report an imaging approach to investigate such DW dynamics with nanoscale spatial resolution employing conventional table-top microscopy techniques. Time-averaged magnetic force microscopy and Kerr imaging methods are applied to quantify the DW oscillations in Permalloy rectangular structures with Landau domain configuration and are complemented by numeric micromagnetic simulations. We study the oscillation amplitude as a function of external magnetic field strength, frequency, magnetic structure size, thickness, and anisotropy and understand the excited DW behavior as a forced damped harmonic oscillator with restoring force being influenced by the geometry, thickness, and anisotropy of the Permalloy structure.

MA 43.5 Thu 16:00 HSZ 401

Tailoring magnetic switching via topology in nanoimprinted networks of Pt/Co/Pt caps on flexible membranes — •Jose A. Fernandez-Roldan[1], Rui Xu[1], Oleksii Volkov[1], Oleksandr Pylypovskyi[1], Ivan Soldatov[2], Andreas Worbs[1], Rene Hübner[1], Rudolf Schäfer[2], Jürgen Fassbender[1], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Leibniz IFW, Dresden, Germany

Perpendicular magnetic bit media consist of regular rigid nanostructured networks where data is stored in decoupled nanostructures. Flexible magnetic nanoelectronic devices rely on curvature-induced effects that introduce topological patterning [1]. We prepared arrays of magnetic bits with a size of 400 nm arranged in close-packed square and hexagonal arrays of Pt/Co/Pt cap-like structures on PDMS elastic membranes by means of nanoprinting and Al anodization. The magnetization reversal process indicates a magnetically decoupled switching process in the individual caps of the square array in contrast to the hexagonal array. Here we propose a method to evaluate this coupling by means of analysis of a series of field-dependent MOKE images. The results indicate that the magnetic coupling between the caps can be quantitatively characterized in terms of a fractal dimension. Overall, these results suggest that the magnetization switching in densely-packed networks can be tailored via topology.

References: [1] D. Makarov et al., Adv. Mater. 34, 2101758 (2022)

MA 43.6 Thu 16:15 HSZ 401

Coherent Correlation Imaging for resolving fluctuating states of matter — •Christopher Klose[1], Felix Buettner[2,3,4], Wen Hu[3], Claudio Mazzoli[3], Kai Litzius[2], Riccardo Battistelli[4], Ivan Lemesh[2], Jason M. Bartell[2], Mantao Huang[2], Christian M. Guenther[5], Michael Schneider[1], Andi Barbour[3], Stuart B. Wilkins[3], Geoffrey S.D. Beach[2], Stefan Eisebitt[1,5], and Bastian Pfau[1] — [1]Max Born Institute, Berlin — [2]Massachusetts Institute of Technology, Cambridge, MA, USA — [3]National Synchrotron Light Source II, Upton, NY, USA — [4]Helmholtz-Zentrum Berlin — [5]Technische Universitaet Berlin

Fluctuations and stochastic transitions are ubiquitous in nanometer-scale systems, especially in the presence of disorder. However, their direct observation has so far been impeded by a seemingly fundamental, signal-limited compromise between spatial and temporal resolution.

Here, we develop coherent correlation imaging (CCI) — a high-resolution, full-field imaging technique that realizes multi-shot, time-resolved imaging of stochastic processes. The key of CCI is the classification of camera frames that correspond to the same physical state by combining a correlation-based similarity metric with powerful classification algorithm developed for genome research.

We apply CCI to study previously inaccessible magnetic fluctuations in a highly degenerate magnetic stripe domain state with nanometer-scale resolution. The spatiotemporal imaging reveals the transition network between the states and details of the magnetic pinning landscape which have been inaccessible so far.

MA 43.7 Thu 16:30 HSZ 401

Origin of helicity-dependent photoconductivity in magnetic and nonmagnetic wires — •Atul Pandey[1,2], Rouven Dreyer[1], Palvan Seyidov[1], Chris Koerner[1], Saban Tirpanci[1], Binoy K. Hazra[2], Stuart Parkin[2], and Georg Woltersdorf[1,2] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle, Germany — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany

We study the opto-electric response in metallic wire structures. The aim is to understand the origin of helicity-dependent photoconductivity. For nonmagnetic metals this effect is generally believed to probe spin polarization. Using magnetic wires we show that this method enables background free imaging of spin textures. Analyzing the physical origin we find that the circular dichroism slightly modulates the absorption. The corresponding thermal modulation explains the measured electrical signals. We apply this result to examine the spin Hall effect induced spin accumulation in heavy metals. Here, we show that previously reported results in nonmagnetic wires are well reproducible, but not related to the spin polarization.

A. Pandey et al., Phys. Rev. B 106, 174420 (2022)