MA 48: Magnetic Instrumentation and Characterization

Time: Friday 9:30–11:45 Location: HSZ 401

MA 48.1 Fri 9:30 HSZ 401

Portable devices for adding Spatial-Intensity-Modulation-mode capabilities to polarized neutron beams — •Denis Mettus[1], Jonathan Leiner[1], Johanna Jochum[2], and Christian Pfleiderer[1] — [1]Physik-Department, Technische Universität München, D-85748 Garching, Germany — [2]Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, Garching, Germany

The MIEZE (Modulated IntEnsity with Zero Effort) resonant spin-echo technique at the RESEDA instrument at FRM II has its optimum resolution at small scattering angles, i.e. SANS type geometries. It is possible to extend the MIEZE application to wide angles by incorporating magnetic Wollaston prisms (MWPs) into the beamline. MWPs can produce controlled spatially intensity modulations in addition to the intensity modulations in time inherent to MIEZE. This would allow correcting to the neutron time of flight differences, extending the MIEZE resolution function to any desired scattering angle.

Additionally, MWPs will be useful in the context of intra-particle mode-entangled neutron beams for potential use in probing many-body quantum entanglement in materials. Finally, the compact and modular nature of the MWPs will allow them to be used to measure diffraction peaks with enhanced resolution at several polarized beam instruments such as KOMPASS, LaDiff, and in general at small angle neutron scattering instruments. We present the plans for the construction of these superconducting MWPs for use at FRM II, and describe the details of their operation and the various possibilities they offer.

MA 48.2 Fri 9:45 HSZ 401

A signal-integrating approach to second harmonic generation imaging and spectroscopy — Lea Forster[1], •Jan Gerrit Horstmann[1], Jannis Lehmann[1,2], Thomas Lottermoser[1], and Manfred Fiebig[1] — [1]Dept. of Materials, ETH Zurich, Switzerland — [2]RIKEN Center for Emergent Matter Science (CEMS), Japan

We investigate the impact of different data normalization procedures on the signal-to-noise ratio in second harmonic generation (SHG) imaging and spectroscopy. Using both nanosecond and femtosecond laser systems in combination with standard detection schemes for SHG, we find that uncorrelated noise in the detection electronics often dominates over the contributions of pulse-to-pulse fluctuations of the laser system, long-term power drifts, or time-dependent changes of the beam profile. Consequently, normalization of SHG signals averaged over thousands of pulses can yield similar signal-to-noise ratios comparable with pulse-to-pulse-normalized data. Based on these results, we demonstrate that state-of-the-art CCD or sCMOS cameras can, in many cases, replace photomultiplier tubes as detectors in pump-probe SHG measurements, enabling ultrafast high-resolution SHG imaging of nonequilibrium dynamics in solids.

MA 48.3 Fri 10:00 HSZ 401

New versatile instruments for magnetism research at ID12 of the ESRF — •A. Aubert[1], K. Skokov[1], G. Gomez[2,3], F. Wilhelm[3], A. Rogalev[3], H. Wende[2], O. Gutfleisch[1], and K. Ollefs[2] — [1]Functional Materials, TU Darmstadt (Germany) — [2]Fac. of Phys., Uni. Duisburg-Essen (Germany) — [3]ESRF, Grenoble (France)

I will introduce two new instruments which have been implemented at the beamline ID12 of the European Synchrotron Radiation Facility (ESRF), in the framework of the ULMAG project funded by BMBF (grant 05K2019). These instruments offer the ESRF users a unique possibility to measure under strictly the same experimental conditions the element-specific X-ray absorption spectroscopy (XAS)/X-ray magnetic circular dichroism (XMCD), XRD simultaneously with the measurement of various macroscopic properties (magnetization, magnetostriction, magnetocaloric, magnetoresistance), as a function of magnetic field (up to 17 T) and temperature (5-325 K) [1].

To demonstrate the potential and features of these scientific instruments, I will present two case studies: (1) FeRh, which has a first-order anti-ferromagnetic to ferromagnetic transition around room temperature (2) HoCo2, which exhibits a first-order ferrimagnetic to paramagnetic transition. These two cases demonstrate new horizons for studying the physics of magnetic materials, where the interplay between the magnetic, structural, and electronic subsystems of the solid is essential.

[1] A. Aubert et al. IEEE Instr. Meas. (2022) 10.1109/TIM.2022.3157001

MA 48.4 Fri 10:15 HSZ 401

XMCD in fluorescence-yield mode can measure the spin-orbit torque switching of both rare-earth and transition-metal sublattices in mesoscale devices of $GdFe_3$ thin films — •James M Taylor[1,2], Chen Luo[1,2], Victor Ukleev[1], Christian H Back[2], and Florin Radu[1] — [1]Helmholtz-Zentrum Berlin for Materials and Energy, 12489 Berlin, Germany — [2]Department of Physics, Technical University of Munich, 85748 Garching, Germany

Ferrimagnets containing one rare-earth and one transition-metal sublattice are of interest both for future spintronic devices and as sandbox materials for exploring ultrafast magnetism. In regard to the latter, ferrimagnetic Gd+Fe has been widely studied, due to its demonstration of all-optical switching (AOS). On the other hand, more interesting for technological applications is current-induced magnetization reversal driven by spin-orbit torques (SOTs). To fully understand SOT switching in ferrimagnets, it is important, as with AOS, to look at the respective behaviour of both sublattices. In this work, we take a step towards making such measurements more readily available: by using conventional, static x-ray magnetic circular dichroism (XMCD) operated in fluorescence-yield mode to measure the relative responses of the Gd and Fe sublattices during an SOT switching process. This was performed using sub-ms current pulses in μm-sized devices fabricated from $GdFe_3$ heterostructures down to 10 nm thick, in-situ in the VEKMAG beamline at the BESSY II synchrotron. We compare this with electrical detection of the switching using simultaneous anomalous Hall effect measurements, which follow the Fe sublattice, as expected.

15 min. break

MA 48.5 Fri 10:45 HSZ 401

Periodogram-based detection of unknown frequencies in time-resolved scanning transmission X-ray microscopy — •Simone Finizio[1], Joe Bailey[1,2], Bart Olsthoorn[3], and Jörg Raabe[1] — [1]Paul Scherrer Institut, Villigen PSI, Switzerland — [2]EPFL, Lausanne, Switzerland — [3]Nordita, KTH Royal Institute of Technology and Stockholm University, Stockholm, Sweden

Pump-probe time-resolved imaging is a powerful technique that enables the investigation of dynamical processes. Signal-to-noise and sampling rate restrictions normally require that cycles of an excitation are repeated many times with the final signal reconstructed using a reference. However, this approach imposes restrictions on the types of dynamical processes that can be measured, namely that they are phase locked to a known external signal (e.g. a driven oscillation or impulse). This rules out many interesting processes such as auto-oscillations and spontaneously forming populations e.g. condensates. In this work we present a method for time-resolved imaging, based on the Schuster periodogram, that allows for the reconstruction of dynamical processes where the intrinsic frequency is not known. In our case we use time of arrival detection of x-ray photons to reconstruct magnetic dynamics without using *a-priori* information on the dynamical frequency. This proof of principle demonstration will allow for the extension of pump-probe time-resolved imaging to the important class of processes where the dynamics are not locked to a known external signal and in its presented formulation can be readily adopted for x-ray imaging and also adapted for wider use.

MA 48.6 Fri 11:00 HSZ 401

Towards switchable probes for advanced Magnetic Force Microscopy — •Aniruddha Sathyadharma Prasad, Rachappa Ravishankar, Rudolf Schäfer, Volker Neu, Bernd Büchner, and Thomas Mühl — IFW Dresden, Helmholtzstraße 20, 01069 Dresden

In magnetic force microscopy (MFM) on samples consisting of non-homogeneous materials and challenging topography, the "magnetic" contrast is often overwhelmed by additional non-magnetic forces arising from differing contact potentials and from changes in the capacitive coupling due to topographical features. The elimination of such interfering signals can be done by a differential imaging process with inverted tip magnetization. Earlier implementations either require precise repositioning of the probe after external switching of the magnetization or application of global magnetic fields which can cause changes in the sample. In our work, we overcome these difficulties by switching the magnetization externally, and using feature matching in the post processing step to eliminate the need for precise repositioning. We also showcase first steps towards an in-situ switching of MFM probes for developing a high-speed differential process within the MFM instrument. This involves the design and fabrication of planar micro-coils capable of providing sufficient magnetic field to switch high quality Iron filled Carbon Nanotube (FeCNT) MFM probes. The switching was verified by applying the inhomogeneous field distributions of planar micro-coils in micromagnetic simulation studies on a FeCNT. Preliminary MFM results from an FeCNT probe interacting with such a coil are also presented.

MA 48.7 Fri 11:15 HSZ 401

Measuring Antiferromagnets at Room Temperature in a Magnetically Shielded Environment — •Michael Paulsen[1], Silvia Knappe-Grüneberg[1], Jens Voigt[1], Allard Schnabel[1], Rainer Körber[1], Michael Fechner[2], and Dennis Meier[3] — [1]Physikalisch-Technische Bundesanstalt, Berlin, Germany — [2]Max Planck Institute for the Structure and Dynamics of Matter, CFEL, Hamburg, Germany — [3]NTNU Norwegian University of Science and Technology, Trondheim, Norway

Antiferromagnetic materials possess zero net dipole magnetization. However, higher-order magnetizations, such as quadrupolar magnetic field contributions, have been predicted for non-centrosymmetric antiferromagnets. Classical low-temperature measurements on Cr_2O_3 [1] indeed indicated an external quadrupole field at 4.2 K [2, 3], but the validity of the results was put into question due to the limited sensitivity of the applied experiment. Here, we present magnetization measurements gained at room temperature in an ultra-low magnetic field environment ($<$ 1 nT). A multi-channel setup with Superconducting Quantum Interference Devices (SQUIDs) and Optically Pumped Magnetometers (OPMs) are used as magnetic field detectors. The results corroborate the emergence of a quadrupolar far-field in Cr2O3, providing new opportunities for the characterization of antiferromagnets and materials with ultra-small remanent magnetization in general.

[1] I. Dzyaloshinskii, Sol. Stat. Comm. 82:7, 579-580, 1992.
[2] D. N. Astrov and N. B. Ermakov, JETP, 59:4, 274-277, 1994.
[3] D. N. Astrov et al, JETP Letters, 63:9, 745-751, 1996.

MA 48.8 Fri 11:30 HSZ 401

Improving the magnetic adhesion of a metal-pipe crawling robot using elastomeric toes — •Muhammad Khan, Kilian Schäfer, and Oliver Gutfleisch — Functional Materials, Institute of Materials Science, Technical University Darmstadt, D-64287 Darmstadt, Germany

To assist human inspectors who examine thousands of kilometres spread oil and gas pipelines, robots are being utilized. A key challenge in robotic pipeline inspection is to ensure that a robot does not fall off a metal pipe. In this work, we show that a two-legged robot crawls on metal pipes using its electromagnetic feet. The robot slip was fixed by introducing an elastomeric toe, implanted under the robot feet. It was shown that the soft toe increased the magnetic adhesion of the feet by enabling the stable stance of the robot feet. The behaviour of the foot-toe was further characterized by conducting surface adaptability test (measurement of toe deformation), calculating its coefficient of friction on different metal pipes, and real-world robot pipe-crawling experiments. Furthermore, use of a magneto-active compound consisting of hard magnetic Nd2Fe14B particles in a thermoplastic polyurethane (TPU) matrix, fabricated to form the fin-ray structure will be also discussed as a potential replacement of the electromagnet. However, such a fin-ray structure would require a large and continuously available activation field which is obviously highly challenging. Here, a concept demonstration at the miniature level can be shown by modifying the robot's shape and size, matching the miniature setup.