MA 44: Magnetic imaging (Experimental techniques)

Time: Thursday 9:30–11:00 Location: H53

MA 44.1 Thu 9:30 H53

Towards determining the spin axis of individual CoO nanoparticles — •David Bracher[1], Tatiana M. Savchenko[1], Martin Testa Anta[2], Veronica Salgueiriño[2], Frithjof Nolting[1], Martino Poggio[3], and Armin Kleibert[1] — [1]Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen, Switzerland — [2]Departamento de Física Aplicada, Universidade de Vigo, 36310, Vigo, Spain — [3]Department of Physics and Astronomy, University of Basel, CH-4056 Basel, Klingelberstrasse 82, Switzerland

Antiferromagnetic materials at the nanoscale are of profound interest for spintronics devices, e.g. spin valves and magnetic random access memories etc. However, the absence of a stray field makes exploring nano-sized antiferromagnetically ordered system very challenging. Here, we use x-ray magnetic linear dichroism (XMLD) spectromicroscopy to investigate the chemical and magnetic properties of individual CoO/Co3O4 core- shell nanoparticles with a diameter of about 100 nm. Complementary high resolution scanning electron microscopy is used to correlate the morphology and the magnetic properties of individual nanoparticles. Temperature-dependent XMLD spectra of single nanoparticles indicate a reversible magnetic phase transition of the CoO core close to Néel temperature of bulk CoO. In addition we observe a pronounced orientation dependent XMLD signal of the nanoparticles. These observations reveal that nano-sized CoO/Co3O4 structures exhibit stable antiferromagnetic order with a preferred spin axis. Our approach paves the way towards characterization of nanoscaled antiferromagnetic spintronics devices.

MA 44.2 Thu 9:45 H53

Nanoscale imaging of ultrafast spin dynamics using high-harmonic radiation — •Sergey Zayko[1], Ofer Kfir[1], Michael Heigl[2], Michael Lohmann[1], Murat Sivis[1], Manfred Albrecht[2], and Claus Ropers[1] — [1]IV Physical Institute, University of Göttingen — [2]Institute of Physics, University of Augsburg

Sources of ultrashort pulses at the extreme-UV and soft-X-rays provide for an ultrafast probe of magnetic textures and topological spin arrangements, such as domain patterns and skyrmions. However, despite a widespread application of high harmonic spectroscopy over the past decade, magnetic imaging using high harmonics has only recently been demonstrated [1]. Here, we report the first demonstration of nanoscale real-space imaging of ultrafast spin dynamics using circularly-polarized high-harmonic radiation. By measuring transient x-ray magnetic circular dichroism (XMCD), femtosecond demagnetization in nanoscale networks of magnetic domains is captured with sub-40-fs temporal and down to 19 nm spatial resolution [2]. This versatile ultrafast magneto-optical microscope will allow for comprehensive studies of ultrafast magnetism in space and time, compatible with applied external magnetic fields, currents, optical excitation and other in-situ capabilities. Furthermore, we believe that polarization-dependent ultrafast high harmonic imaging can be extended to other ultrafast phenomena, including structural dynamics and femtochemistry [3]. [1] Kfir, Zayko et al., Science Advances 3, no. 12, eaao4641(2017) [2] Zayko et al., Th1B.4. 10.1364/CLEOPR (2018) [3] Kraus et al., Nat. Rev. Chemistry 2, 82-94 (2018)

MA 44.3 Thu 10:00 H53

A Concept for a Magnetic Particle Imaging Scanner with Halbach-Arrays — •Anna C. Bakenecker[1], Jonas Beuke[1], Peter Blümler[2], Anselm von Gladiss[1], Thomas Friedrich[1], and Thorsten M. Buzug[1] — [1]Institute of Medical Engineering, University of Lübeck, Germany — [2]Insititute of Physics, University of Mainz, Germany

Magnetic particle imaging (MPI) is a new medical imaging technique that enables three-dimensional real-time imaging of magnetic nanoparticles used as tracer material. Although it is not in clinical use yet, it is highly promising, since no ionizing radiation is necessary. Therefore, MPI is suitable as an interventional imaging technique. The upscaling of MPI is a major challenge as even preclinical scanners featuring a small bore have an immense power consumption for the electromagnetical generation of the desired magnetic field geometries. A concept is proposed, which consists of mechanically rotatable Halbach-Arrays in dipole and quadrupole configurations. Even though permanent magnets are used, this concept features a high flexibility in terms of adjusting the magnetic field geometries. It is possible to adjust the field gradient, the field of view as well as the sampling rate. Therefore, it is possible to choose between overview scanning, real-time imaging and detailed visualization of a chosen region of interest. A short introduction into MPI will be given and the concept of the proposed scanner will be explained.

MA 44.4 Thu 10:15 H53

Quantitative nanoscale magnetic imaging with a cryogenic single spin magnetometer — •Qi-Chao Sun[1], Andreas Brunner[1], Tetyana Shalomayeva[1], Marc Scheffler[2], Rainer Stöhr[1], and Jörg Wrachtrup[1,3] — [1]3. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]1. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [3]Max Planck Institute for Solid State Research,Heisenbergstraße 1, 70569 Stuttgart, Germany

The electron spin of nitrogen-vacancy (NV) defects in diamond offer a promising platform for probing condensed matter systems by measuring the surface magnet field quantitatively with an operating temperature range from cryogenic temperature to above room temperature and a dynamic range spanning from DC to GHz. Here, we report our operation of cryogenic scanning nano magnetometer with single NV defect in diamond. To demonstrate the performance of our system, we measure the magnetic field on the surface of bulk Cu2OSeO3. With an NV defect about 10 nm from the sample surface, we directly measure the magnetic field component along the NV axis which shows a clear stripe structure with a period of 80 nm, attributed to the helical spin order. Thanks to the quantitative magnetic imaging, we reconstruct the vector field from the measurement result and obtain an image of the helical magnetic field. The development of NV-based magnetic imaging will enable more previously inaccessible studies of physics of spins and currents in correlated electron materials and devices.

MA 44.5 Thu 10:30 H53

A new scanning reflection x-ray microscope for magnetic imaging in the EUV range — •Andreas Schümmer[1], Hans-Christoph Mertins[1], Claus Michael Schneider[2], Roman Adam[2], Daniel Bürgler[2], Larissa Juschkin[3], and Ulf Berges[4] — [1]University of Applied Sciences, Münster Stegerwaldstraße 39, 48565 Steinfurt, Germany — [2]Forschungszentrum Jülich, Wilhelm-Johnen-Straße, 52428 Jülich, Germany — [3]Rhein Westfälische Technische Hochschule Aachen, Templergraben 55, 52062 Aachen, Germany — [4]TU Dortmund, Zentrum für Synchrotronstrahlung, Maria-Goeppert-Mayer-Str. 2, 44227 Dortmund, Germany

The advancing miniaturization in magnetic data storage and spintronics requires imaging characterization methods that can also investigate buried layers with element-selectivity and high sensitivity. Here, first magnetic domain images obtained with a new scanning reflection x-ray microscope (SRXM) are presented. Free standing zone plates and a scanning device were developed for the extreme ultra violet (EUV) range available at the beamline 12 at the DELTA synchrotron facility. The transversal magneto optical Kerr effect (T-MOKE) at the Fe 3p edge under 30° grazing incidence was applied to imaging the magnetic domain structure of buried Fe layers in Au/Fe/Cr-wedge/Fe/Ag samples, where the Cr thickness varies between 0.3 and 0.7 nm and thus gives rise to a transition between antiferromagnetic and ferromagnetic magnetic interlayer coupling between the Fe layers. The advantage of working in the EUV range is an increased intensity of the reflected light, which is about 2 orders of magnitude larger than at the 2p edges.

MA 44.6 Thu 10:45 H53

Soft X ray magnetic tomography — Aurelio Hierro-Rodriguez[1], Carlos Quiros[2], Andrea Sorrentino[3], Ricardo Valcarcel[3], Luis M Alvarez Prado[2], Jose Ignacio Martin[2], Jose M Alameda[2], Stephen McVitie[1], Eva Pereiro[3], Maria Velez[2], and •Salvador Ferrer[3] — [1]School of Physics and Astronomy University of Glasgow G12 8QQ, Glasgow (UK) — [2]Departamento de Fisica, Universidad de Oviedo, 33007 Oviedo, Spain — [3]ALBA Synchrotron, 08290 Cerdanyola del Valles, Spain

Soft X ray transmission microscopy with circularly polarized photons tuned at specific resonant energies allows to image magnetic textures by exploiting the dichroic absorption contrast which depends on the

angle of the magnetization and X ray beam. Changing their relative orientations allows determining the orientation of the magnetization of the sample [1]. We have recently developed 3D magnetic reconstruction tomography [2] which allows to reconstruct the magnetization at ~ 30 nm resolution and to localize magnetic singularities in thin films (thickness up to ~300 nm) . These results will be illustrated in a permalloy/NdCo/permalloy trilayer where magnetic bifurcations at the top and bottom permalloy layers are clearly separated. Our method is well suited for identifiying buried magnetic features in multilayers.

1.- C. Blanco-Roldan et al.,Nat Comm. (2015) DOI: 10.1038/ncomms9196 2.- A. Hierro-Rodriguez, J. Synchrotron Rad.(2018)24, 1144