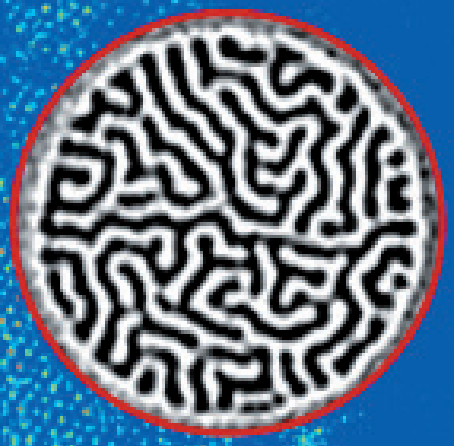
New Trends in X-ray Scattering and Spectroscopy from Magnetic Materials.

XIV. Research Course on X-Ray Sciences
25-27 March 2015, DESY Hamburg



- New X-ray techniques applied to magnetic materials
- Ultrafast Demagnetization
- X-ray Magnetic Circular Dichroism
- All optical control of magnetism
- X-ray Holography
- Photoelectron spectroscopy

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Accelerators | Photon Science | Particle Physics

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DESY

General information

Oral sessions The oral sessions will be held in the lecture hall of Bldg. 61.

Poster session The poster session will take place in the lobby of the CFEL building (Bldg. 99) on Wednesday 19:00. There will be food and drinks for all participants.

Registration The registration will start on Wednesday 25 March 2015 at 10:00h in front of the lecture hall.

Social event The conference dinner will take place on Thursday 26 March 2015 at 18:30 at the DESY canteen.

Meals

Breakfast
If you stay at the Novotel Hamburg Arena, breakfast will be provided there. If you stay at the DESY guest house you may have breakfast at the DESY cafeteria (opens at 07:00h, building 9) at your own expenses

Lunch
You may have lunch at the DESY canteen (building 9) at your own expenses

Dinner
For the poster session we will serve light dinner. On Thursday, 26 March we will have the conference dinner (see above)

Supermarkets LIDL: From the main gate at Notkestrasse turn right and follow the street (700–800m). LIDL will be clearly visible on the left side of the street at the next junction.

PENNY: From the main gate at Notkestrasse walk straight down the street "Zum Hünengrab". On the right side, at the end of the street you will find the supermarket

ATM You will find a cash machine in the foyer of the DESY canteen (Bldg. 9).

DESY WLAN Guests, with unregistered MAC-Adresses will be mapped to our "Guest WLAN", it is a DESY Class-C Network which provides DHCP-Support.

Before you will get internet access, you have to open your Internet browser with any requested Internet Site. Your request will be redirected to our Portal Server, a DESY form opens automatically. There you have to fill out the required fields. After submitting this form it will take about 1 minute before your requested Internet Site appears. Up to now you can use the Internet connectivity for a maximum of 90 days. **Note:** *The DESY-Guest WLAN is* ***unencrypted****. That means, for transferring sensitive data (e.g. passwords) secure protocols are mandatory (e.g. SSH and VPN).*

Programme

Wed 25.03.2015

10:00	Registration	
11:00	Welcome	Grübel
11:15	Ultrafast magnetization dynamics	Beaurepaire
12:15	Lunch	
14:00	Magnetism on the time and length scale of the exchange interaction	Rasing
15:00	Ultrafast demagnetization: A transport effect	Acremann
16:00	Coffee break	
16:30	X-ray holographic imaging of (dynamic) nanomagnetic structures	Eisebitt
17:30	Facility visits	
19:00	Poster Session	

Thu 26.03.2015

09:00	Resonant X-ray scattering studies of correlated electron systems	Mc Morrow
10:00	Resonant magnetic scattering at 3rd generation synchrotron sources	Strempfer
11:00	Coffee break	
11:30	New trends in probing magnetic structure and dynamics via (nuclear) resonant scattering of synchrotron radiation	Röhlsberger
12:30	Lunch	
14:00	Probing magnetic nanostructures using coherent x-rays	Roy
15:00	Time-resolved x-ray detected FMR on spintronic materials	van der Laan
16:00	Coffee break	
16:30	Ultrafast dynamics of magnetic domain structures probed by coherent Free-Electron Laser light	L. Müller
17:00	Interface physics of magnetic oxides: Insights from x-ray spectroscopy	M. Müller
18:30	Dinner	
	PIER-Dinnertalk	Blick

Fri 27.03.2015

09:00	Ferromagnetism in low dimensional Co/Pt systems	Oepen
10:00	Tunable ultrafast magnetic response in ferromagnetic materials	Aeschlimann
11:00	Coffee break	
11:30	tbd	*Scherz*
12:30	end	

Ultrafast magnetization dynamics

Eric Beaurepaire

Institut de Physique et Chimie des Matériaux de Strasbourg, France

The magnetization of ferromagnetic films can be controlled down to the femtosecond time scale by the use of ultrashort laser pulses [1]. However, interpretation of involved phenomena remains largely debated. The talk will introduce the main achievements and key concepts of femtomagnetism, that started developing pump and probes techniques where magnetic transients are caught using the magneto-optical effects. In a second part, it will be shown that the ultrafast quenching of the magnetization leads to the emission of a THz electromagnetic wave that is indeed detected and whose characteristic features will be discussed. The recent development of soft x-rays radiation sources such as femto-slicing sources on synchrotron rings [2] or x-ray free electron lasers, delivering femtosecond pulsed x-ray bursts, bring qualitatively new information in the field since core level absorption measurements allow probing selectively atomic species. Moreover, the application of sum rules on x-ray magnetic circular dichroism experiments allows a quantitative estimation of magnetic moments and their splitting into spin and orbit contributions. The talk will present such results obtained for alloys including Cobalt and Palladium or Rare-Earth elements and discuss the role of the spin-orbit interaction in the ultrafast demagnetization of thin films.

[1] Beaurepaire, E., Merle, J. C., Daunois, A. & Bigot, J.-Y. Ultrafast spin dynamics in ferromagnetic nickel. Phys. Rev. Lett. 76, 4250-4253 (1996).

[2] Stamm, C. et al. Femtosecond modification of electron localization and transfer of angular momentum in nickel. Nature Mater. 6, 740-743 (2007).

Magnetism on the time and length scale of the exchange interaction

Theo Rasing

Radboud University, Institute for Molecules and Materials, Nijmegen, Netherlands

Ultrafast laser techniques have revealed extraordinary responses of the magnetization in many materials that cannot be explained by equilibrium descriptions of magnetism. Various suggestions for explanations include nanoscale non-equilibrium spin dynamics, but experimental data are limited by the spatial resolution of optical laser techniques. In this talk I will present experimental results obtained with the Femtoslicing facility of the Helmholtz-Zentrum Berlin and the Stanford femtosecond x-ray laser that give unique insights into the nanoscale spin dynamics following optical laser excitation. Experiments were performed on the ferrimagnetic alloys GdFeCo and TbFe. Our studies reveal nanoscale chemical and magnetic inhomogeneities in GdFeCo and nonlocal transfer of angular momentum between sublattices and nanoregions. The realization that femtosecond laser induced all-optical switching (AOS) as observed in ferrimagnets exploits the exchange interaction between their sublattices, opens the way to engineer magnetic materials for AOS. We also demonstrate that, using plasmonic antennas, AOS can be achieved in TbFe on a length scale of tens of nanometers. Recent results and an outlook to probe and control magnetic order on the femtosecond time and nanometer length scale will be discussed.

Ultrafast demagnetization: A transport effect

Yves Acremann

ETH Zürich, Laboratorium für Festkörperphysik, 8093 Zürich, Switzerland

The ultrafast loss of magnetization caused by a femtosecond laser pulse is still not well understood. One of the important contributions is spin flip scattering in the bulk of the magnetic material, mediated by the presence of phonons. The second contribution is the creation of spin currents, which transport spin angular momentum from the magnetic film into the substrate, where spin slips can take place outside of the view of the observer [1]. In this lecture, an overview over recent x-ray experiments concerning ultrafast demagnetization and spin-transport will be given. In addition, a simple thermodynamic model describing the generation of ultrafast diffusive spin currents will be discussed.

[1] Battiato et al., PRL p.105, 027203 (2010).

X-ray holographic imaging of (dynamic) nanomagnetic structures

Stefan Eisebitt

Institut für Optik und Atomare Physik, Technische Universität Berlin, Germany

Continuously, accelerator based x-ray sources are becoming more "laser-like" in that a higher fraction of the radiation they emit is coherent. X-ray free-electron lasers are spearheading this development, with the European XFEL coming into operation as the world-wide brightest source of coherent x-rays soon. How can this coherent illumination with x-rays be utilized in magnetism research? Holography with x-rays takes advantage of the coherence and short wavelength of these beams to provide us with nanoscale images of materials and dynamic processes [1]. I will explain the basics and specialties of holography with x-rays. Examples include in particular dynamic imaging of magnetic structures via holography with x-ray magnetic circular dichroism contrast on a nano-, pico- and femtosecond time scale [2,3].

[1] S. Eisebitt et al., Lensless imaging of magnetic nanostructures by X-ray spectro-holography, Nature 432, 885 (2004).

[2] C. von Korff Schmising et al., Imaging Ultrafast Demagnetization Dynamics after a Spatially Localized Optical Excitation, Physical Review Letters 112, 217203 (2014).

[3] F. Büttner et al., Dynamics and inertia of skyrmionic spin structures, Nature Physics 11, 225 (2015).

Resonant X-ray scattering studies of correlated electron systems

Des McMorrow

London Centre for Nanotechnology, University College London, UK

In the quest for materials with novel functional properties there is an ongoing need to understand any ordering in their ground state and its associated excited states. For strongly correlated materials the ordering may involve the charge, magnetic or orbital degrees of freedom. Resonant elastic X-ray scattering (REXS) is well established for studying directly various possible types of ordering in the ground state. Compared with other more traditional techniques, such as neutron scattering, the resonant aspect of the technique endows it with an electron shell and orbital specificity. REXS experiments also enjoy very high sensitivity, allowing experiments to be performed on crystals down to the micron scale. Resonant inelastic X-ray scattering (RIXS), by contrast, has emerged more recently for studying coherent excitations, and can in favourable circumstances enjoy the same advantages as REXS. In this talk an introduction will be given to resonant elastic and inelastic X-ray scattering, with examples chosen from recent highlights in the physics of correlated electron systems.

Resonant magnetic scattering at 3rd generation synchrotron sources

Jörg Strempfer

DESY, Hamburg, Germany

Magnetic x-ray diffraction is a relativistic scattering process yielding only small diffracted intensities. But by tuning the x-ray energy close to the absorption edges of the magnetic elements, resonant magnetic x-ray scattering can result in significantly higher intensities. Some further advantages of resonant magnetic scattering are the element selectivity and the strong dependence of the resonant scattering cross section from the polarization of the incident x-ray polarization allowing determination of origin and orientation of magnetic moments. Since the first resonant scattering experiments at synchrotron radiation sources, continuous improvements of the technique have helped to greatly enhance the possibilities for the investigation of magnetic materials in the hard x-ray range. The availability of variable incident polarization and polarization analysis of the diffracted beam has meanwhile become indispensable for magnetic diffraction experiments. Complementarity to the superior neutron diffraction for studying magnetism stems from possibility of using high intense small x-ray beams on small samples and to investigate neutron absorbing materials. In this lecture, possibilities of investigation of ferromagnetic and antiferromagnetic order in strongly correlated electron systems will be introduced. Examples of x-ray resonant and non-resonant magnetic scattering and combinations of both as well as x-ray resonant magnetic reflectivity will be given.

New trends in probing magnetic structure and dynamics via (nuclear) resonant scattering of synchrotron radiation

Ralf Röhlsberger

Deutsches Elektronen-Synchrotron DESY and The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany

The unique properties of the nuclear resonances of Mössbauer isotopes render them very sensitive probes for magnetic structure and dynamics in thin films and nanostructures. The combination of nuclear resonant scattering of synchrotron radiation with advanced x-ray scattering methods enables one to explore hitherto unexplored regions in the phase space of magnetic excitations. A striking example is the determination of the spin precession trajectory in thin films that are subject to microwave excitation at GHz frequencies [1]. These studies exhibit a promising potential to probe the depth profile and the lateral structure of magnetic excitations in artificially structured systems. A first step into this direction is the investigation of the relaxational dynamics in magnetic nanoparticles that are forming during a sputter-deposition process [2]. Combining resonant magnetic x-ray scattering with a polarimetric detection method, one could record the intermediate scattering function I(q,t) of spinwave excitations in a sample for a given q, potentially with a single shot of an x-ray laser [3].

[1] L. Bocklage et al, Phys. Rev. Lett. (accepted, 2015), arXiv:1410.3689 [cond-mat.mtrl-sci]

[2] D. Erb et al, in preparation

[3] R. Röhlsberger, Phys. Rev. Lett. 112, 117205 (2014)

Probing magnetic nanostructures using coherent x-rays

Sujoy Roy

Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley CA 94720, USA

Nanoscale magnetic interfaces and structures can give rise to emerging spin textures that can have unique physics and new functionalities. By exploiting the unique spatial sensitivity of coherent soft x-ray beams it is possible to unravel novel dynamic and static properties of magnetic systems. We have performed X-ray Photon Correlation Spectroscopy using resonantly tuned x-ray beam to study thermally induced domain fluctuation of a helical antiferromagnet near the ordering temperature. The fluctuations exhibit a behavior which is similar to some of the universal characteristics of jammed systems such as polymers, gels, etc. We will also discuss topological phases and magnetic defects in artificial spin ice structures that mimic "magnetic monopoles". By manipulating magnetic field it is possible to generate a particular ordered structure of monopole defects that imparts orbital angular momentum to Bragg diffracted soft x-ray beams. These examples indicate that coherent x-rays are powerful probe to unravel new phases and spin textures in magnetic systems.

Time-resolved x-ray detected FMR on spintronic materials

Gerrit van der Laan

Magnetic Spectroscopy Group, Diamond Light Source, Didcot, Oxfordshire, UK

Improved understanding of precessional magnetization dynamics is essential for the continued development of high frequency magnetic devices such as hard disk drives and spin oscillators. In the past, conventional ferromagnetic resonance (FMR) has been used extensively to determine fundamental parameters that affect magnetism in thin films using resonance frequencies (related to internal and applied fields) and relaxation (determined by damping of the resonance). However, the growing complexity of many modern ferromagnetic materials and devices requires the development of measurement techniques that reveal in a more direct fashion the microscopic origin of relevant interactions. Recently, x-ray detected FMR (XFMR) has emerged as a powerful synchrotron radiation based tool that can be used to study the element-selective magnetization dynamics. Magnetic and chemical contrast in XFMR is obtained by x-ray magnetic circular dichroism (XMCD), while the phase difference of the magnetization precessions is monitored using a stroboscopic measurement technique. A unique property of time-resolved XFMR is the visualisation of the magnetization precession of each individual layer in a magnetic device. Examples are shown where the measured amplitude and phase response of the magnetic layers provide a clear signature of spin transfer torque (STT) coupling due to spin pumping. Spin pumping through a topological insulator is also discussed.

Interface physics of magnetic oxides: Insights from x-ray spectroscopy

Martina Müller

Peter Grünberg Institut, Forschungszentrum Jülich, Germany

Photoelectron spectroscopy is the most direct and powerful tool to probe the microscopic electronic strutcure of matter. In the lecture, we will consider seceral recent developments in the use of hard X-ray photoemission (HAXPES) – which gives access to the true bulk and interface electronic structure – for the study of magnetic oxide materials, their nanostructures and interfaces from our group and others as illustrations. Various experimental methods of HAXPES will be discussed, which electronic, chemical and magnetic properties can be obtained with these techniques and how to understand and interprete these spectra. These involve studies on buried multilayers and interfaces of transition-metal and rare earth magnetic oxides for spintronics uses, and routes towards in operando band-alignment measurements in magnetic oxide-semiconductor hybrids.

Ferromagnetism in low dimensional Co/Pt systems

Hans Peter Oepen

Institut für Nanostruktur- und Festkörperphysik, Universität Hamburg, 20355 Hamburg

Co/Pt multilayers are a hot topic in current research. Films can be tuned to exhibit perpendicular magnetic anisotropy and in such multilayers strong impact due to the spin orbit coupling of Pt is found in transport, e.g. in current induced domain wall movement. We have investigated the magnetotransport and magnetothermo properties of ultrathin Co layers sandwiched by Pt. We report a new magnetotransport effect that shows a strong thickness dependence which indicates that the effect is originating from the scattering at the Co/Pt interfaces. The interface scattering is also responsible for Seebeck coefficients that exhibit a so far unknown dependence on magnetization orientation. We fabricate nanodots starting from such Co/Pt multilayers. Utilizing the anomalous Hall effect we have investigated the switching of single nanodots in the blocked and the superparamagnetic state. Assuming macro-spin behavior we obtain an unexpected broad span of attempt frequencies. Possible explanations for the high values are given.

Tunable ultrafast magnetic response in ferromagnetic materials

Martin Aeschlimann

Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany

The study of ultrafast dynamics in magnetic materials provides rich opportunities for greater fundamental understanding of correlated phenomena in solid-state matter, because many of the basic microscopic mechanisms involved are as-yet unclear and are still being uncovered. In this research area, new developments in laser-based femtosecond x-ray and extreme-ultraviolet sources make it possible to probe element-specific spin dynamics in multispecies magnetic systems. These nascent optical tools therefore provide new and detailed information that is mostly not accessible by using visible light, and allow for the design of experiments that can help to identify the microscopic mechanisms of ultrafast spin dynamics.

List of posters

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3	MOORE, James	Magnetic Field Sample Environments at the European XFEL
4	VALERIO, Joana	Liquid Jets for Experiments on Complex Liquids
5	NACK, Annemarie	Investigation of rheological and dynamic properties of composites consisting of viscous hydrogels and anisotropic hematite particles
6	DAVID, Behal	Polar symmetry of natural MnWO4 domain single crystals
7	GATTERMANN, Ulf	Crystal growth of In & Na - doped multiferroic MnWO4 phases
8	CIMATTI, Irene	A complete surface study of an evaporable lanthanide-based Single Molecule Magnet
9	REICHEL, Victoria	Magnetite synthesisin the presence of biological additives
10	GHAISARI, Sara	Assembled Nanomagnets: Ferromagnetic Resonance Spectroscopy of Magnetotactic Bacteria
11	YAROSLAVTSEV, Alexander	X-ray spectroscopy of magnetic rare-earth transition metal pnictides
12	DONNELLY, Claire	Element specific X-ray phase tomography at the nanoscale
13	SENDETSKYI, Oles	X-ray scattering in artificial spin ice
14	MÜLLER, Leonard	Ultrafast Dynamics of Magnetic Domain Structures Probed by Coherent Free-Electron Laser Light
15	MOLODENSKIY, Dmitry	Powder Diffraction with a Scanning 2D-area Detector Using Synchrotron Radiation
16	KUBÁNIOVÁ, Denisa	Ferric oxide nanoparticles: Insight into the phase composition and the magnetic structure of ϵ-polymorph from Mössbauer Spectroscopy
17	BAGSCHIK, Kai	X-ray resonant magnetic scattering study of domain sizes in wedged Co/Pd multilayer samples
18	KUZKOVA, Nataliia	tbd
19	LE GUYADER, Loic	Ultrafast demagnetization in rare-earth alloys: the role of spin-orbit coupling
20	ROSE, Max	Max Rose, Water Window Ptychographic Imaging with Characterized Coherent X-Rays
21	SCHWARZ, Marcus	Magnets with geometric frustration via high pressure synthesis
22	MILIŃSKA, Ewelina	Magnetic and structural properties of Co/Mo systems.
23	SALEEM, zashair	Investigation of Piezoelectricity in bismuth based piezoelectric material (Bi12SiO20) to a fast change of electric field by time resolved X-ray diffraction method
24	BEHRMANN, Malte	Large-amplitude spin oscillations triggered by nonequilibrium strongly correlated t2g electrons
25	MANNA, Kaustuv	Spin Canting in Ferromagnetic Lu2MnNiO6

26	KUSCHEL, Timo	Static magnetic proximity effects in Pt/NiFe2O4 and Pt/Fe bilayers investigated by x-ray resonant magnetic reflectivity
27	PAL, Anirban	Multiferroic Behavior in Elemental Selenium below 40 K: Effect of Electronic Topology
28	CARDIN, Vincent	High flux table-top ultrafast soft X-ray source generated by high harmonic generation.
29	PANDEY, Rishikesh	Stability of Crystallographic Phases and Phase Transition Studies in (1-x)Bi(Ni1/2Ti1/2)O3-xPbTiO3 Solid Solutions
30	ERB, Denise	Self-assembling magnetic nanostructures: Studies of morphology and magnetism with in-situ GISAXS and Nuclear Resonant Scattering
31	YUAN, Ye	High Curie temperature InMnAs with strong PMA synthesized by ion implantation
32	WEIER, Christian	Laser-induced Modification of Co/Pt Multilayer Films studied with Tabletop Resonant Magnetic Scattering
33	SEN, Kaushik	Impact of superconductor/ferromagnet (SC/FM) interfaces on the transport properties of SC/FM heterostructures
34	CHIRKOVA, Alisa	Phase decomposition in FeRh alloys
35	WESTERSTRÖM, Rasmus	Endofullerene single-molecule magnets: From bulk to submonolayers on surfaces
36	KOSTANYAN, Aram	tbd
37	WEISE, Bruno	X-ray tomography and magnetic characterization of magnetocaloric composites
38	BYKOVA, Iuliia	A high-performance MAXYMUS X-ray microscope for magnetic materials imaging
39	FRIETSCH, Björn	Orbital-resolved ultrafast magnetization dynamics of gadolinium
40	DZEMIANTSOVA, Liudmila	Topologically Protected Magnetic Helix Imaged with Mössbauer Spectroscopy and X-ray Polarimetry
41	BLUSCHKE, Martin	Induced Antiferromagnetic Order and Feedback Across the LaNiO3/DyScO3 Interface
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