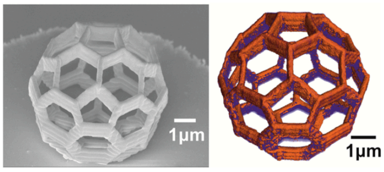
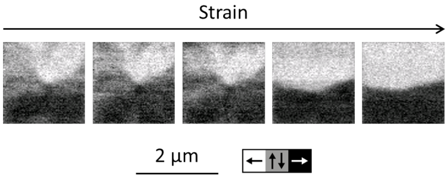




SLS Symposium on

Magnetism

Tuesday, May 3rd, 2016

10:00 to 12:15, WBGB/019

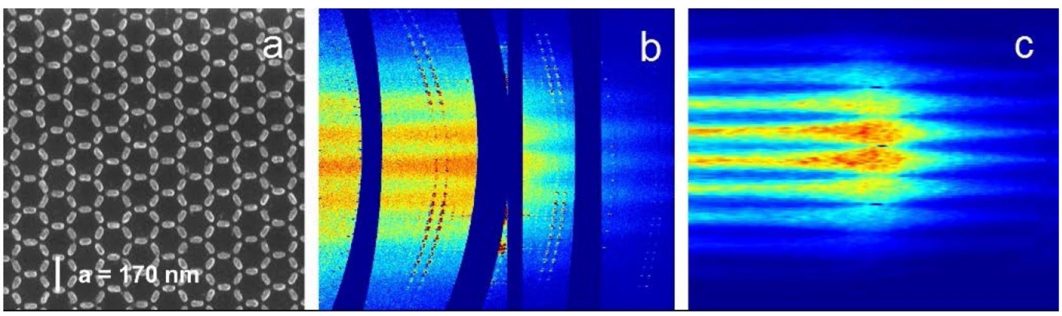
10:00 X-ray magnetic scattering in thermally active artificial spin ice
O. Sendetskyi, L. Anghinolfi, V. Scagnoli, G. Möller, N. Leo, A. Alberca, J. Perron, N. Jaouen, J. Kohlbrecher, J. Lüning, U. Staub, and L. J. Heyderman,

10:30 Towards Magnetic tomography: Element-Specific X-ray Resonant Phase Tomography at the Nanoscale
C. Donnelly, M. Guizar-Sicairos, V. Scagnoli, M. Holler, T. Huthwelker, A. Menzel, I. Vartiainen, E. Müller, E. Kirk, S. Gliga, F. Wilhelm, F. Guillou, A. Rogalev, C. Detlefs, J. Raabe and L. J. Heyderman.

11:00 Coffee

11:15 Symmetry Lowering and Multiferroicity in the chiral incommensurate helimagnet $Ba_3TaFe_3Si_2O_{14}$
M. Ramakrishnan, Y. Joly, Y. W. Windsor, L. Rettig, A. Alberca, E. M. Bothschafter, R. Ballou, V. Simonet, P. Lejay, V. Scagnoli and U. Staub

11:45 Investigation of the magneto-elastic coupling with high-resolution x-ray magnetic imaging
S. Finizio, E. Kirk, S. Wintz and J. Raabe.



X-ray magnetic scattering in thermally active artificial spin ice

Sendetskyi O.[1,2], Anghinolfi L.[1,2], Scagnoli V.[1,2], Möller G.[3], Leo N.[1,2], Alberca A.[2], Perron J.[4], Jaouen N.[5], Kohlbrecher J.[2], Lüning J.[4], Staub U.[2] and Heyderman L. J.[1,2]

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Artificial spin systems consist of mesoscopic single domain magnetic islands typically arranged on a two-dimensional lattice and coupled together via magnetostatic interactions. Such systems have attracted considerable interest due to their complex magnetic phase diagrams [1] and moment excitations which resemble emergent magnetic monopoles [2]. Here, we apply X-ray Resonant Magnetic Scattering (XRMS), measured at the RESOXS endstation of the SIM beamline at the SLS, to look at zero-field magnetic correlations in thermally active artificial kagome spin ice with sub-70 nm islands, see fig. 1a. The energy of circularly polarized X-rays was tuned to the Fe L_3 absorption edge, yielding sensitivity to the magnetisation. Magnetic diffuse scattering was measured at several temperatures above the blocking point of a thermally active artificial kagome spin ice (fig. 1b) [6]. Experimental data can be understood using Monte Carlo simulations and subsequent numerical calculation of scattering patterns using kinematic scattering theory [3, 4, 5], see fig. 1c. Magnetic diffuse scattering indicates zero-field ice-rule correlations of the kagome ice I phase with “two moments in – one moment out" and vice versa at each vertex [6]. They are reminiscent of the correlations in atomic spin ice that produce magnetic diffuse scattering with pinch points or bow ties [7, 8].

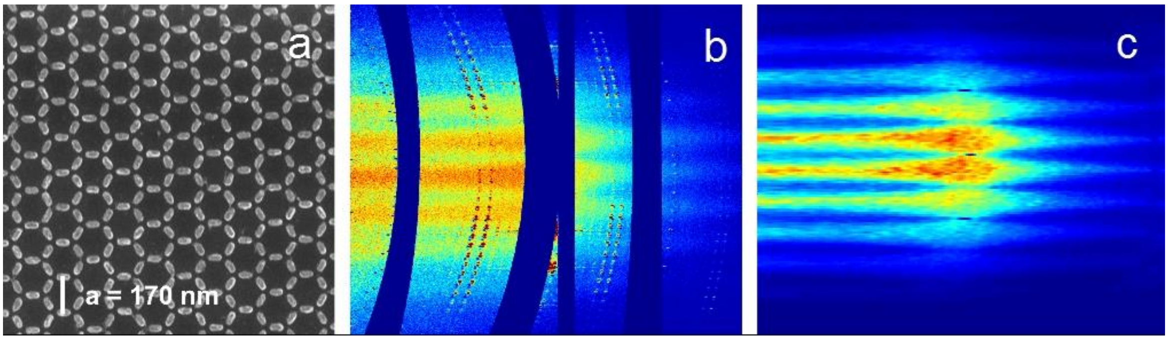

Figure 1: (a) SEM image of the artificial kagome spin ice with sub-70 nm islands. (b) Experimental scattering pattern from artificial kagome spin ice obtained at Fe L_3 edge [6]. (c) Numerical calculation of the magnetic scattering pattern using moment configurations from Monte Carlo simulations. Magnetic scattering is well reproduced indicating kagome ice I magnetic phase [6].

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Towards Magnetic tomography: Element-Specific X-ray Resonant Phase Tomography at the Nanoscale

Claire Donnelly[1,2], Manuel Guizar-Sicairos [2], Valerio Scagnoli [1,2], Mirko Holler [2], Thomas Huthwelker [2], Andreas Menzel [2], Ismo Vartiainen [2], Elisabeth Müller [2], Eugenie Kirk [1,2], Sebastian Gliga [1,2], Fabrice Wilhelm [3], François Guillou [3], Andrei Rogalev [3], Carsten Detlefs [3], Jörg Raabe [2] and Laura J. Heyderman [1,2].

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With three dimensional artificial and composite materials offering opportunities for applications within many fields, a full structural and chemical characterisation is critical for further progress. However, whilst there are a variety of complementary magnetic imaging techniques suitable for imaging 2D magnetic systems, new techniques with which to study 3D magnetic systems must be developed. Here we first present resonant ptychographic tomography, where we achieve element-specific 3D characterization of a cobalt-coated artificial buckyball polymer scaffold at the nanoscale. By performing ptychographic x-ray tomography at and far from the Co K edge, we are able to locate the Co layer in our sample with a 3D spatial resolution of 25 nm, and with a quantitative study of the electron density we can determine that the Co layer is oxidised [1]. Secondly, by performing ptychographic scans with circularly polarized X-rays (hard X-ray dichroic ptychography), we show that one can exploit X-ray magnetic circular dichroism to obtain images of the magnetic configuration of a micrometre-thick FeGd multilayer at both the Gd L_3 and the Fe K edges, demonstrating 50 nm spatial resolution in 2D [2]. Further combination of dichroic ptychography with current tomographic techniques will enable mapping of the magnetization vector field with sub-100 nm spatial resolution within micrometer-size magnetic systems.

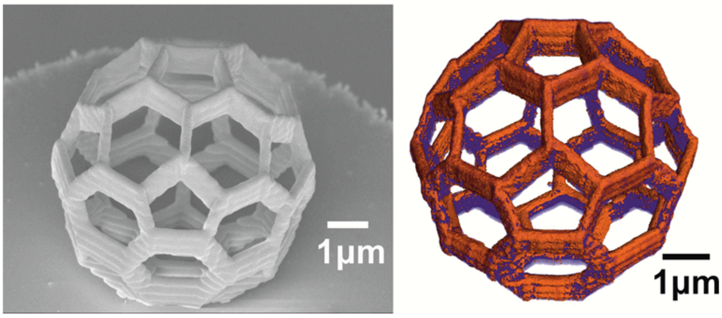

Figure 1: (a) An SEM image of the cobalt-coated artificial buckyball, investigated with resonant ptychographic tomography. A rendering of the element specific tomogram is shown in (b), where the cobalt is shown in orange and the polymer resist in blue.

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Symmetry Lowering and Multiferroicity in the chiral incommensurate helimagnet $Ba_3TaFe_3Si_2O_{14}$

M. Ramakrishnan[1], Y. Joly[2], Y. W. Windsor[1], L. Rettig[1], A. Alberca[1], E. M. Bothschafter[1], R. Ballou[2], V. Simonet[2], P. Lejay[2], V. Scagnoli[1,3], and U. Staub[1]

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Fe-based langasites [$Ba_3(M)Fe_3Si_2O_{14}$ where M=Nb,Ta] are chiral antiferromagnets which crystallize in an enantiopure phase. In the ground state, the magnetic moments in the triangular lattice of these langasites rotate from one unit cell to the next in a helical fashion with an incommensurate propagation vector ***(0,0,τ)*** with ***τ*** ≈ 1/7. Dzyaloshinskii-Moriya interactions cause magnetic Fe^{3+} ions possess out-of-plane dipole moments sinusoidally modulated with the same propagation vector resulting in a helical butterfly structure. Recent neutron scattering experiments have found that the in-plane magnetic moments are "bunched" into an irregular helix, due to magnetic anisotropy. At the same time, bulk polarization studies, Moessbauer spectroscopy as well as neutron scattering studies present contradicting pictures regarding the crystal symmetry in the low temperature magnetic phase, which is fundamental to understand the magnetoelectric interactions. We have performed extensive soft x-ray diffraction experiment at the Fe $L_{2,3}$ and O K-edges to study magnetic and higher harmonic reflections. To explain the differences in the observed spectral shapes, detailed ab-initio calculations based on the FDMES code have been carried out. Our results lead to a better understanding of the origin of the satellite reflections, and indicate a further lowering of crystal symmetry.

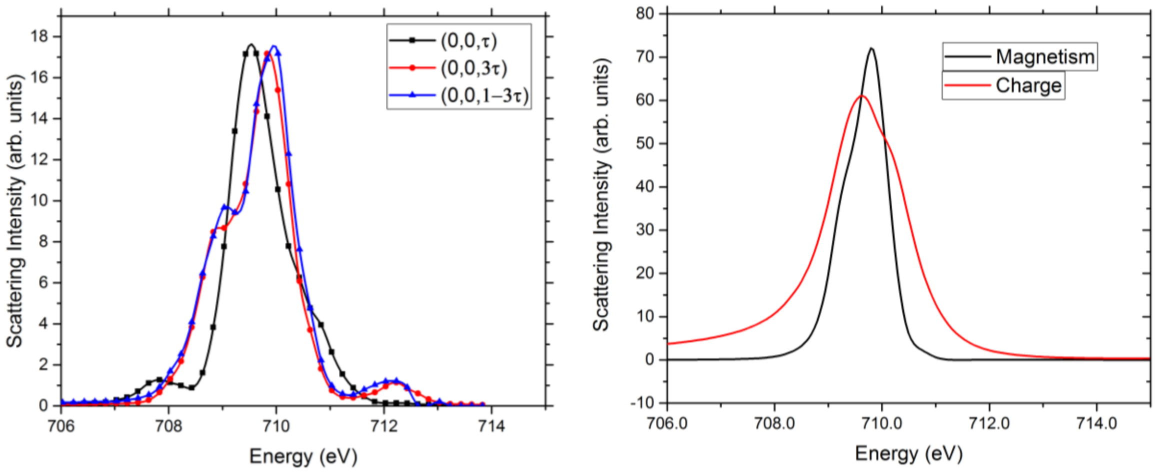

Figure 1: (left) The experimentally observed spectral shapes of the magnetic satellites in $Ba_3TaFe_3Si_2O_{14}$ at the Fe L_3 resonance; (right) Calculated energy dependence of the anisotropic charge and magnetic scattering multipoles contributing to the (0,0,τ) satellite reflection (Calculations based on the spherical harmonic expansion utility of the FDMNES code for a pure dipole E1-E1 process)

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Investigation of the magneto-elastic coupling with high-resolution x-ray magnetic imaging

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The control of the magnetic configuration of ferromagnetic materials without the application of magnetic fields has recently attracted much interest, as the achievement of such a goal would drastically reduce the energy consumption involved in the magnetization switching in devices such as e.g. magnetic memories. This has led, in particular, to an active investigation of both artificial and natural multiferroic materials [1], focusing on the magneto-elastic and magneto-electric couplings (i.e. materials where the magnetization can be controlled either by an applied strain or by an electric field).

One of the promising artificial multiferroic materials based on magneto-elastic coupling consists of the combination of a magnetostrictive (e.g. Ni) and a piezoelectric material (e.g. PMN-PT) [2-4]. For this system, the straining of the magnetostrictive material (by applying an electric field to the piezoelectric) leads to considerable modifications of the magnetic configuration of the magnetostrictive material, which can be reliably and reversibly controlled [2, 3]. However, due to intrinsic limitations of the piezoelectric materials (e.g. regarding their RF properties), the dynamical behavior of the magnetostrictive material as a function of the applied strain was not yet investigated.

Here, we employ an alternative path for the generation of a static strain without the use of piezoelectric materials. This setup employs x-ray transparent silicon nitride membranes, which enable also the investigation of the sample with high-resolution scanning transmission x-ray microscopy (STXM), not possible with piezoelectric substrates. The setup is based on an environmental gas cell used for in-situ imaging of atmospheric particulates [5]: by applying a pressure difference between the two sides of an x-ray transparent membrane, the resulting bending of the membrane itself (see Fig. 1) can be used to generate relative strains on the order of $\Delta\varepsilon/\varepsilon \approx 10^{-4}$ (calculated [6]), i.e. comparable to those that can be generated by piezoelectric materials. In this presentation, the first measurements on magnetostrictive materials using this setup will be illustrated.

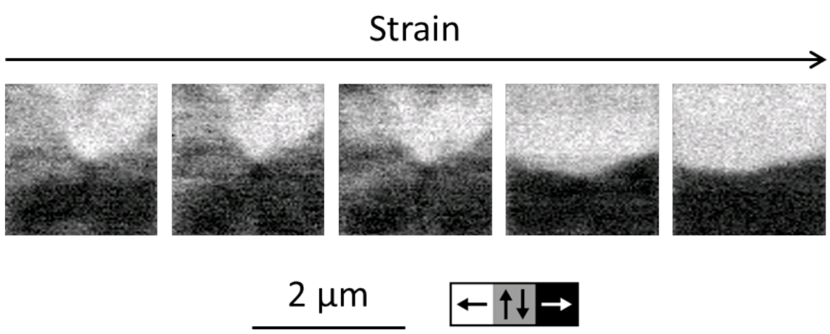

Figure 1: XMCD-STXM images of a 2 m Ni square as a function of an applied uniaxial tensile strain. A strain-dependent uniaxial anisotropy can be observed. The grayscale arrow illustrates the direction of the magnetic contrast in the images.

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