Current status of synchrotron x-ray techniques

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To date, synchrotron radiation has been used to probe a wide variety of magnetic properties. The unique feature that distinguishes techniques that utilize synchrotron x-rays from other magnetic measurements is their ability to obtain both elemental and orbital specific magnetic information. This distinctive capability is of critical importance in developing an understanding of the magnetism in novel new multi-constituent magnetic materials. Various spectroscopic, imaging and scattering methods have been developed to use x-rays in the study magnetic materials.

The most commonly employed spectroscopic technique has been x-ray magnetic circular dichroism (XMCD). XMCD measures the difference in the x-ray absorption with the helicity or a circularly polarized incident parallel and antiparallel to the sample magnetization. XMCD is extremely sensitive technique that has been used to perform measurements on samples with moments less than 0.01 μ_B, sample volumes less than 0.01 monolayer, and with a time resolution100 ps resolution. Furthermore, XMCD measurements have been used to extract the orbital contribution to the magnetic moment.[1-5] XMCD is the only technique capable of providing this type of information on such minute samples. Although these studies have provided a tremendous amount of knowledge, the need to perform XMCD measurements on samples with even smaller moments and sample volumes is required, particularly in the area of cluster magnetism. The development of phase-locked XMCD detection techniques should increase these sensitivity limits by an order of magnitude or more.

X-ray photo-emission microscopy (X-PEEM) has been extensively used to image magnetic domain structures and dynamics. The current capabilities of this technique can be used to obtain images with a special resolution of 50 nm and a temporal resolution of 100 ps.[7,8] Current nano-structured materials, however, have moved to much smaller length scales. Many of the speakers expressed the need to obtain images with resolutions down to 5nm. Currently such capabilities are being developed at the ALS, whether the APS should also invest in such capabilities should be considered.

Magnetic x-ray scattering provides a complimentary technique to neutron scattering measurements. X-ray measurements provide element specific information, high q-resolution, and the ability to probe very small sample volumes. Simultaneous real and reciprocal space information can obtained by using focusing optics in combination with magnetic diffraction techniques. This combination has only recently been used to obtain images of the domains of complicated magnetic structures. The figure below illustrates one such example of an image of the spiral antiferromagnetic domains Dy

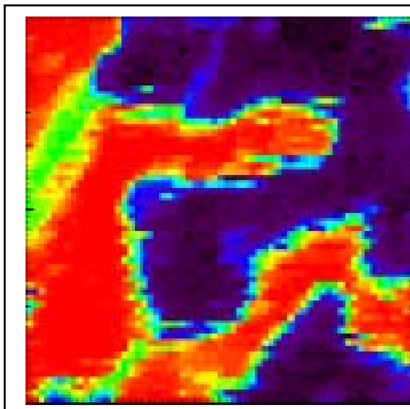

Figure: 125x125 μm^2 image of the right- and left- handed spiral magnetic domains in Dy metal.

metal. The current the resolution of such images is approximately 1 μm. Imaging the topology of such structures near the domain walls, however, requires and an addition order of magnitude improvement in the resolution. Improved resolution would also be beneficial in using magnetic diffraction to probe phase-segregated materials on the nanometer length scales. Furthermore, developing techniques for imaging ferromagnetic domains using diffraction methods can provide critical information on the correlation of these domains though a magnetic ordering temperatures.

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