Materials Science & Engineering Seminar Series

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Mapping Three-Dimensional Magnetic Fields at the Nanoscale with Electron Microscopy

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ABSTRACT: Magnetism arises from the angular momentum of charges. Electrons therefore provide a useful probe to measure and image magnetic fields. For example, the most common magnetic electron microscopy techniques, Lorentz TEM and differential phase contrast (DPC) microscopy, can be used to quantitatively image the magnetic induction projected through a thin magnetic sample under varying external conditions, such as during an applied field sweep or temperature variation. We use LTEM to investigate magnetic topological features and domain wall chirality in Fe-based thin films. However, both LTEM and DPC are sensitive to gradients in magnetic-induced phase shifts imparted to electrons transmitted through the sample, which provides some limitations: they are not sensitive to the magnetic field vector components parallel to the beam, typically perpendicular to the plane of the sample, their sensitivity to the in-plane magnetic field components requires a tradeoff with spatial resolution, and they only image the average field projected through the specimen. We develop and apply multimodal electron microscopy techniques to provide the missing information. Electron interferometry and surface-sensitive scanning electron microscopy with polarization analysis (SEMPA) can provide the missing information. I will discuss how we use these various methods to provide more complete pictures of 3D structure of magnetic features such as skyrmions.

BIOGRAPHY: Prof. Ben McMorran joined the Physics Department faculty at University of Oregon in Fall 2011. He is a member of the UO Materials Science Institute (MSI) and the Oregon Center for Optical, Molecular, and Quantum Sciences (OMQ). Working under the guidance of Prof. Alex Cronin, he earned his Ph.D. from the University of Arizona in 2009, with the thesis entitle "Electron Diffraction and Interferometry Using Nanostructures". Shortly thereafter, he joined the Electron Physics Group in the Center for Nanoscale Science And Technology (CNST) at NIST in Gaithersburg, where he worked with John Unguris and Jabez McClelland on magnetic electron microscopy. The McMorran group researches electron physics and magnetism. For example, the lab uses electron microscopes as “optics benches” for experiments in electron matter wave interferometry and methods to coherently “sculpt” free electron wavefunctions, such as vortex states that carry quantized angular momentum. The lab also applies these tools to new forms of electron microscopy. He is a 2013 Department of Energy Early Career Award recipient.

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