Materials Science & Engineering Seminar Series

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X-Raying Non-Trivial Spin Textures

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ABSTRACT: Spin textures are the foundation of properties and behavior of magnetic materials and drive the functionality of magnetic devices. Topology and frustration that impact spin textures have recently attracted significant scientific interest and led to intense research e.g. in magnetic skyrmions (Sk) and artificial spin ice systems (ASI) addressing a broad spectrum of challenging scientific and technological questions, including stability, dynamics, nucleation, and transport. So far, SK and ASI have been treated foremost as two-dimensional spin textures, however, recent investigations have opened the door to a conceptually next leap, which are three-dimensional nanoscale size magnetic spin textures (3D-spin-textures) e.g., chiral bobbers, magnetic hopfions, and skyrmion tubes. Advanced characterization tools that provide magnetic sensitivity to spin textures at high spatial resolution, ultimately at buried interfaces and in all three dimensions [1], and at high temporal resolution to capture the spin dynamics across scales, are therefore of large scientific interest.

Magnetic soft X-ray spectro-microscopies [2] provide unique characterization opportunities to study the statics and dynamics of spin textures in magnetic materials combining X-ray magnetic circular dichroism (X-MCD) as element specific, quantifiable magnetic contrast mechanism with spatial and temporal resolutions down to fundamental magnetic length, time, and energy scales.

Current developments of x-ray sources aim to increase dramatically the coherence of x-rays opening the path to new techniques, such as ptychography [3] or x-ray photo-correlation spectroscopy (XPCS) [4] that allow unprecedented studies of nanoscale heterogeneity, complexity, and fluctuations.

I will review recent achievements and future opportunities with magnetic x-ray spectro-microscopies. Examples will include static properties and dynamic behavior of various magnetic skyrmion [5,6] textures with potential application to novel magnetic logic and storage devices, as well as results from an XPCS study at LCLS with a novel 2-pulse scheme that allowed to discover an unexpected and drastic change of the correlation times in nanoscale spin fluctuations near phase boundaries, i.e., in the skyrmion phase, and near the boundary with the stripe phase of a multilayered Fe/Gd system [4].

Finally, I will present a study on ferromagnetic liquid droplets, which could establish a complete paradigm shift in magnetic materials, that combine characteristics of liquid, such as reconfigurability and short range spatial and temporal correlations with ferromagnetism, which so far has been confined to condensed matter [7].

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[1] A. Fernandez-Pacheco, et al., Nature Comm 8 15756 (2017)
[2] P. Fischer and H. Ohldag, Report on Progress in Physics 78 094501 (2015)
[3] X. Shi, et al, Appl Phys Letter 108, 094103 (2016)
[4] M. H. Seaberg, et al, Phys Rev Lett 119 067403 (2017)
[5] S. Woo, et al., Nature Materials 15 501 (2016)
[6] N. Kent et al, Appl Phys Lett (2019) under review
[7] X. Liu et al, Science Science 365 264 (2019)

BIOGRAPHY: Dr. Peter Fischer received his PhD in Physics (Dr.rer.nat.) from the Technical University in Munich, Germany in 1993 on pioneering work with X-ray magnetic circular dichroism in rare earth systems and his Habilitation from the University in Würzburg, Germany in 2000 based on his pioneering work on Magnetic Soft X-ray microscopy.

Since 2004 he is with the Materials Sciences Division at Lawrence Berkeley National Laboratory in Berkeley CA. He is Senior Staff Scientist and Principal Investigator in the Non-Equilibrium Magnetic Materials Program and currently also Deputy Division Director at MSD. His research program is focused on the use of polarized synchrotron radiation for the study of fundamental problems in magnetism. Since 2014 he is also Adjunct Professor for Physics at the University of California in Santa Cruz.

Dr. Fischer has published more than 200 peer reviewed papers and has given more than 300 invited presentations at national and international conferences. He was nominated as Distinguished Lecturer of the IEEE Magnetics Society in 2011. For his achievements of “hitting the 10nm resolution milestone with soft X-ray microscopy” he received the Klaus Halbach Award at the Advanced Light Source in 2010.

Dr. Fischer is Fellow of the APS and IEEE.

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