Time-resolved x-ray diffraction microscopy for nanoscience

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Time-resolved X-ray diffraction provides direct measurement of structural dynamics, accessing critical spatiotemporal parameter spaces that are difficult to reach otherwise. In this talk, I will overview the recent progress on nanoscale structural characterization, followed by two recent examples to show how ultrafast x-ray diffraction can help us understand nanoscale structural dynamics. The first example uncovers collective excitation in topological ferroelectric nanostructures [1]. A unique soft mode is identified as a pair of oscillating polar vortex cores that can be significantly tuned by strain around room temperature. The discovery of tunable vortexons opens a new avenue for high-frequency dielectrics and optoelectronics applications. The second example reveals the structural phase evolution during the first-order phase transition in FeRh. The nanoscopic insights of phase transition can help guide the design of energy-efficient magnetic recording devices. Last, I will provide an outlook for multimodal, multiscale x-ray imaging techniques at DOE facilities.

[1] Qian Li, Vladimir A. Stoica, Marek Paściak, Yi Zhu, Yakun Yuan, Tiannan Yang, Margaret R. McCarter, Sujit Das, Ajay K. Yadav, Suji Park, Cheng Dai, Hyeon Jun Lee, Youngjun Ahn, Samuel D. Marks, Shukai Yu, Christelle Kadlec, Takahiro Sato, Matthias C. Hoffmann, Matthieu Chollet, Michael E. Kozina, Silke Nelson, Diling Zhu, Donald A. Walko, Aaron M. Lindenberg, Paul G. Evans, Long-Qing Chen, Ramamoorthy Ramesh, Lane W. Martin, Venkatraman Gopalan, John W. Freeland, Jirka Hlinka, Haidan Wen, "Subterahertz collective dynamics of polar vortices", ***Nature***, 592, 376-380 (2021)

[2] Youngjun Ahn, Mathew J. Cherukara, Zhonghou Cai, Michael Bartlein, Tao Zhou, Anthony DiChiara, Donald A. Walko, Martin Holt, Eric E. Fullerton, Paul G. Evans, and Haidan Wen," Ultrafast Nanoimaging of Photoinduced Structural Phase Transition in FeRh", submitted

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