

Virtual Hard X-Ray Collaboration Seminar Series

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Title: Crystal Optics Development for Ultrafast Coherent X-ray Pulse Manipulation

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Abstract:

X-ray Free Electron Lasers (FELs), with the femtosecond coherent x-ray pulses and their unprecedented peak brightness, have found numerous applications spanning across wide areas of research fields [1]. This naturally led to a growing interest in extending the optical laser measurement methodologies to atomic time and length scale [2] and calls for the development of optical components and systems to manipulate x-ray laser pulses in the multidimensional space of time, spectrum, space and trajectory. In this talk, I will summarize our developments of x-ray crystal optics at the Linac Coherent Light Source in the form of hard x-ray delay lines to generate identical double x-ray pulses with controllable femto- and pico-second-level time separations [3-5], in an effort to realize the measurement schemes including interferometry, wave mixing, and dynamic light scattering with an angstrom wavelength beam [6, 7]. I will also show other possibilities and concepts of the applications of crystal optics, including generating terawatt x-ray pulses via chirped pulse amplification mechanism [8].

[1] Bostedt, C., et al. "Linac coherent light source: The first five years." *Reviews of Modern Physics* 88.1, 015007, 2016

[2] Seddon, E. A., et al. "Short-wavelength free-electron laser sources and science: a review." *Reports on Progress in Physics* 80.11: 115901, 2017

[3] Roseker, W., et al. "Performance of a picosecond x-ray delay line unit at 8.39 keV." *Optics Letters* 34.12: 1768-1770, 2009

[4] Zhu, D., et al. "Development of a hard x-ray split-delay system at the Linac Coherent Light Source." *Advances in X-ray Free-Electron Lasers Instrumentation IV*. Vol. 10237. International Society for Optics and Photonics, 2017.

[5] Li, H., et al. "Generation of highly mutually coherent hard-x-ray pulse pairs with an amplitude-splitting delay line." *Physical Review Research* 3.4: 043050, 2021

[6] Tanaka, S., and Mukamel S. "Coherent X-ray Raman spectroscopy: a nonlinear local probe for electronic excitations." *Physical Review Letters* 89.4: 043001, 2002

[7] Gutt, C., et al. "Measuring temporal speckle correlations at ultrafast x-ray sources." *Optics Express* 17.1: 55-61, 2009

[8] Li, H., et al. "Femtosecond-Terawatt Hard X Ray Pulse Generation with Chirped Pulse Amplification on a Free Electron Laser." *submitted*, 2022