

## Towards Single Shot coherent imaging of domain fluctuations

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Experiments at the MID station of the European XFEL measured Bragg coherent diffraction patterns from 20 nm epitaxial thin films of the prototype high-temperature superconductor material,  $\text{La}_{1.88}\text{Sr}_{0.12}\text{CuO}_4$  (LSCO), which has a structural phase transition between a low-temperature orthorhombic (LTO) phase and a high-temperature tetragonal (HTT) phase near room temperature. Speckled diffraction patterns were recorded in a long run of 1002 pulse trains of 140 pulses at 2.2 MHz. Fluctuations were clearly seen from frame to frame of the data stream. Correlation analysis showed better correlation of the diffraction within the pulse trains than between trains and it was concluded this was more likely due to beam position fluctuations rather than the sample. A Complex-valued Computational Neural Network was developed [1] that could reproducibly invert the diffraction patterns to images of the structural domains associated with the epitaxial growth of the samples, which are phase shifted relative to each other. It was necessary to merge about 20 of the most correlated diffraction patterns within each pulse train to have enough statistics for reliable inversion. But in future experiments at LCLS, it would be expected to get enough signal in a single shot to invert to a MHz train of images.

[1] "Ultrafast Bragg Coherent Diffraction Imaging of Epitaxial Thin Films using Deep Complex-valued Neural Networks" Xi Yu, Yuewei Lin, Longlong Wu, Jiecheng Diao, Jialun Liu, Jörg Hallmann, Ulrike Boesenberg, Johannes Möller, Anders Madsen, Tadesse Assefa, Emil S. Bozin, Yue Cao, Hoydoo You, Dina Sheyfer, Stephan Rosenkranz, Samuel Marks, Paul Evans, David Keen, Ivan Bozovic, Mark P.M. Dean, Shinjae Yoo, Ian K. Robinson, submitted to npj Computational Materials (2023)