Universal Iterative Phasing Method for Near-Field and Far-Field Coherent X-Ray Diffraction at the APS

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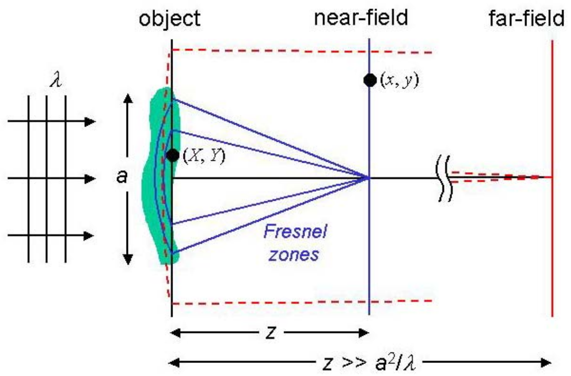
Coherent x-ray diffraction is usually categorized into two distinct regimes: the near-field Fresnel or in-line holography regime, and the far-field Fraunhofer regime. In the near-field regime, coherent imaging allows the detection weakly absorbing objects due to phase-contrast or phase-enhanced effects. Various methods of phase retrieval in the Fresnel regime include transport of intensity equation method and the holo-tomography algorithm using the self-imaging principle for different spatial frequencies at several detector distances. For far-field diffraction, because of the direct Fourier transform relationship between real space density and reciprocal space amplitudes, an iterative phasing method has been widely applied and proved to be very effective.

In this paper, we present recent activities to enhance the imaging capabilities at the APS, and a universal iterative method for evaluation of wave-field propagation and for phase retrieval of a continuous diffraction pattern in both far-field and near-field regimes. Our method (see figure at right) embeds Fresnel-zone construction on an original object to form a phase-chirped distorted object, which is then Fourier transformed to form a diffraction pattern. We show several examples of phase reconstruction to illustrate this approach, which extends the applicability of Fourier-based iterative phasing algorithms into the near-field regime. Based on our results, we discuss the potential advantages of near-field diffraction with few Fresnel zones in high-resolution structural investigations of noncrystalline materials.



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