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Structure recovery by new convergent beam techniques[1]

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Coherent diffractive imaging (CDI) is an emerging methodology for very high resolution lensless imaging, a major application of which is the imaging of single biomolecules using X-ray free electron laser sources. Typically, the object of interest is required to be isolated and is illuminated with a planar highly spatially coherent beam. The diffraction pattern produced by the object is then measured in the far-field. The reconstruction of the object distribution is related to the diffracted field via a Fourier transform and the imaging problem can be treated as a phase recovery problem. Iterative phase-recovery techniques that use the known size of the isolated object are employed. The iterative methods have a tendency to stagnate and are very sensitive to the illumination having imperfect spatial coherence. More recently, it has been proposed that there are benefits to illuminating the object with a spherical beam. Benefits include more reliable convergence of the iterative algorithm and a greater degree of robustness to imperfect coherence. The resulting diffraction pattern is also obtained in the far-field but the diffraction pattern is described by the Fresnel formalism. In the paper I describe our experimental work on the development of Fresnel CDI. In particular I will discuss how the use of a finite expanding wave can be used to define a finite region within an otherwise infinite object and so permit the application a coherent diffractive imaging to extended objects, enabling CDI to evolve into a generally applicable and reliable form of high resolution X-ray imaging. I will also discuss our recent work on coherence measurement and show how a measurement of the coherence properties of an X-ray beam can be included into the imaging method and thereby lead to further improvements in the broad applicability of CDI.

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