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Speckle-based X-ray Phase Contrast Imaging at Free-Electron Lasers

Free-electron lasers (FEL) provide researchers unprecedented ultra bright, coherent, monochromatic single pulse x-rays for x-ray phase contrast imaging at the submicron scale. This has accelerated our understanding in quantum physics, material science and chemistry that underpin many of our present-day endeavors in fusion energy, biotechnology and engineering materials.
The problem is that tiny particles (debris) in the way of the x-ray beam optics scatter the x-rays and produce a speckle pattern that obscures the image. The speckle pattern and low frequency structure fluctuate on a pulse-to-pulse basis due to the stochastic nature of FEL and is distorted by the sample. This prevents the extraction of quantitative information. Consequently, simply dividing out the speckle pattern using a sample-free image does not eliminate the image artefacts (this is the conventional method for flat field correction).
Our solution is to reconstruct from the distorted speckle pattern the sample phase [1]. The speckle pattern acts as a reference pattern like in wavefront sensing. As the speckle pattern traverses the object, the object is imprinted onto the speckle pattern through distorting it. We present a specklebased phase retrieval algorithm to transform the speckle pattern and into a phase map.

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