Coherent Diffractive Imaging Using Phase Front Modifications

The high degree of coherence of today's x-ray sources has promoted the development of various diffractive imaging techniques that are not hindered by imperfections in optical elements. In general, coherent diffractive imaging (CDI) uses the intensity distribution of a diffracted wave to deduce information about the specimen, such as attenuation and phase shift distributions. A common challenge in CDI is recovering the phase component of the wave field, which is lost in the measurement.

Iterative algorithms are typically used to reconstruct the image of a specimen from a single diffraction pattern. But this procedure requires a substantial number of iterations, has difficulties with complex-valued exit waves, and may not lead to a unique solution. Furthermore, one of the most stringent limitations to this 'conventional' CDI method is the need for isolated objects (the so-called support constraint).

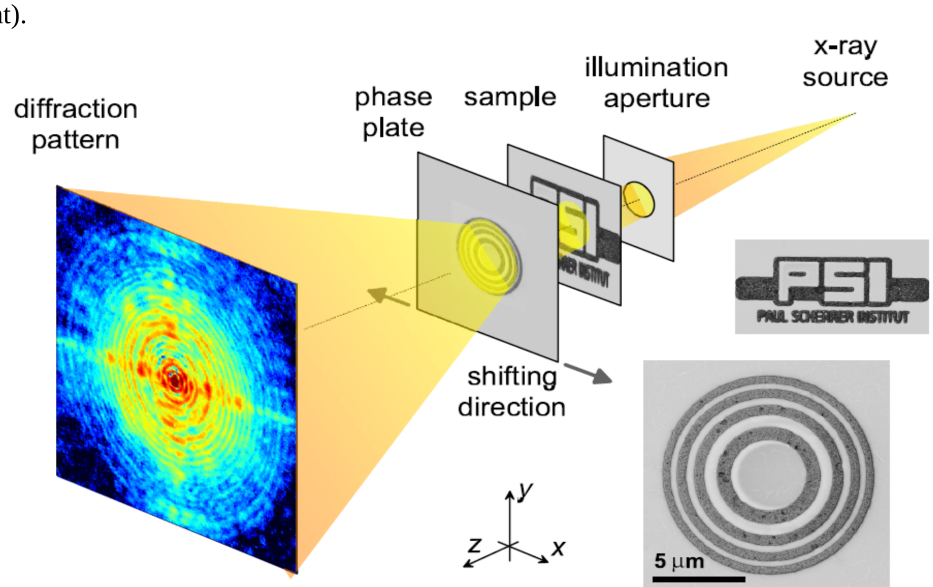

Figure 1: Schematic of the experimental setup.

Here, we report on a new technique that takes advantage of phase front modifications after the sample to generate different diffraction patterns. As a result, the altered exit waves force each exposure to have a unique interference pattern and compensate for the lack of phase information. Similar to a previously developed method [Rodenburg et al., Phys. Rev. Lett. **98**, 034801 (2007)], complementary information directs the convergence of a numerical algorithm and solves ambiguities in the reconstruction. In contrast to the conventional techniques, a sharp support is not needed and extended specimens may be imaged. Additionally, since both the computational and data acquisition times can be short (seconds), this new technique provides the opportunity for real time image reconstruction. With regards to microscopy, this technique is optimal for specimens that fit within a coherent area of the radiation, in our case a few micrometers in size. In this Letter, we report on the technique and results from the first demonstration experiment.

The method is applicable and has a future in laser light, electron, and x-ray microscopy. The fast convergence and data acquisition times make this technique suitable for both real time imaging and three-dimensional nanoscale tomography. These points lead us to believe that this technique with improved data quality can assist the investigation of small material science and biological samples.

We gratefully acknowledge the assistance of C. Borca, X. Donath, D. Grolimund, and B. Meyer during the experiments. We also thank A. Menzel, D. K. Satapathy, and P. Thibault for fruitful discussions. This work has been performed at the microXAS beamline of the Swiss Light Source, Paul Scherrer Institut, Villigen, Switzerland.

Publications

- **Coherent Diffractive Imaging Using Phase Front Modifications**
  I. Johnson, K. Jefimovs, O. Bunk, C. David, M. Dierolf, J. Gray, D. Renker, and F. Pfeiffer
  Physical Review Letters **100**, 155503 (2008)
  http://link.aps.org/abstract/PRL/v100/e155503 (17.04.2008)

*To whom correspondence should be addressed: ian.johnson@psi.ch