Wavefront sensing using ptychography at FELs

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Since its first successful experimental demonstration [1] X-ray ptychography has been increasingly applied within imaging experiments particularly for synchrotron radiation-based applications. The robustness of the developed algorithms enables the retrieval not only of the complex-valued transmission functions of unknown specimens but also of the wavefield interacting with them to form the collected scattering patterns. This feature has been exploited at 3rd generation X-ray sources for characterising wavefronts and hence optics [2] and – in controlled conditions - has been applied at an X-ray free-electron laser (FEL) as well [3].

While traditional methods are now able to retrieve the average wavefield used throughout a ptychographic scan, the pulsed beams produced by FELs typically entail a greater variability than that of beams produced by other synchrotron sources, making the task of retrieving wavefronts of individual FEL pulses non-trivial. We propose an approach which combining mixed-state analysis [4] and orthogonal probe relaxation [5] techniques allows to retrieve wavefronts of individual FEL pulses from ptychographic scans without the use of any filtering optics but a flat attenuator [6]. We present results obtained from experiments performed on a test pattern at the Linac Coherent Light Source (LCLS) and FERMI (Fig. 1).

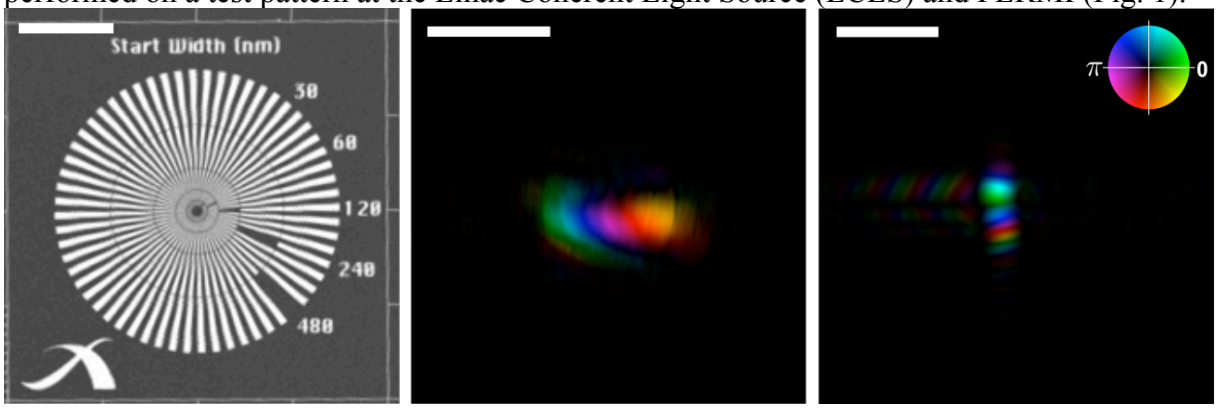

Fig. 1. (a) SEM image of the gold test pattern used as object within the ptychographic scans; scalebar 10 µm. Main mode of reconstructed probes at LCLS (b) and FERMI (c); scalebars 3 µm, amplitude and phase mapped to value and hue respectively.

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