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## **Wavefront sensing of individual XFEL pulses using ptychography**

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The characterization of the wavefront dynamics is important for many X-ray free-electron laser (XFEL) experiments, in particular for coherent diffractive imaging (CDI), as the reconstructed image is always the product of the incoming wavefront with the object. An accurate understanding of the wavefront is also important to optimize peak power densities to make use of the tightest possible focal spots. Here, we demonstrate that ptychography can be used to reconstruct the full wavefront profile of each individual pulse at the focus of the Atomic, Molecular and Optical (AMO) endstation at the Linac Coherent Light Source (LCLS). Our method uses the mixed-state formalism to retrieve dominant beam components from an ensemble of pulses, which are then used to reconstruct every individual pulse. Among all pulse characterization techniques, our approach works in conditions closest to those in real applications, since it provides the wavefront profile in the focal plane without the need on any other component in the beam path. When integrated as a routine beam diagnostic tool, the described method will benefit the success of XFEL imaging experiments.

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