Time-Domain Ptychography

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One of the most robust techniques solving the so-called phase problem in X-ray diffraction imaging is ptychography. It produces the correct real-space image if the illumination beam is known [1], but works even if it is unknown [2]. In 2015 we were the first to extend ptychography to the time domain and further to the reconstruction of temporal objects. In comparison to existing algorithms, ptychography minimizes the data to be recorded and processed, and thereby significantly reduces the computational time for reconstruction.

We show that time-domain ptychography is related to Gabor frames allowing us to use the theory of frames to calculate the range of optimal reconstruction parameters, which so far are determined mostly via trial and error. Then, we experimentally verify time-domain ptychography with the probe pulse (1) being known, (2) unknown but derived from the temporal object, and (3) completely unknown [3,4,5]. Next, we demonstrate that the properties of time-domain ptychography are especially well suited for the reconstruction of complex light pulses with large time-bandwidth products [6], for example supercontinua from nonlinear fibers or attosecond pulses from high harmonic sources [7].

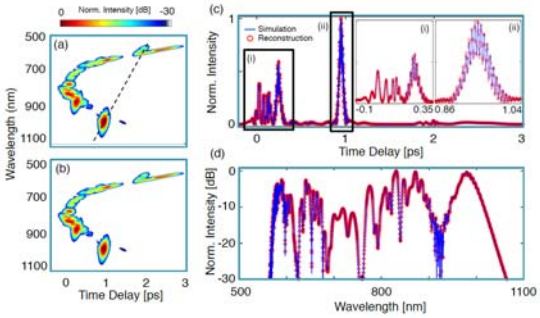

Figure 1. (a) Simulated and (b) reconstructed spectrogram of a supercontinuum pulse emerging from a nonlinear fiber. (c) Temporal intensity and (d) logarithmic spectrum.

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