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Flat-field correction of highly-dynamic processes

Using hard coherent x-rays, as produced in PETRA III and European XFEL, objects with a size of µm to nm can be imaged with full-field phase contrast, single-pulse imaging. With single-pulse imaging, specifically dynamic processes on the nanosecond-timescales can be investigated. A lens-less imaging setup, which works without an optical instrument between the object and the detector, allows for an aberration-free detection of the object.

A recorded single-pulse hologram of the object under investigation is disturbed by artifacts stemming from the illumination. The origin of these artifacts are aberrations in the optics e.g. figure errors or surface roughness. For further analysis the artifacts have to be removed, which is commonly achieved by a flat-field correction i.e., the x-ray image of the object of interest is divided by an empty-beam image.

This approach intrinsically assumes temporal stability of both illumination and object. In the case of XFEL experiments, the pulse-to-pulse fluctuations stemming from the SASE process violate this assumption. For the imaging conducted at PETRA III, in addition to vibrations in the beamline's optical components, the object itself incorporates dynamic movements.

The common case of the flat-field correction can be improved by recording an empty-beam image-series.With selected principal components of principal component analysis (PCA) of the empty-beam series, the flat-field per object-image can be reconstructed. A careful selection of these principle components and its automation allows for improved results.

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