Wavefront metrology and propagation characteristics of extreme UV and soft X-ray sources

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Based on long-time experience in wavefront metrology at visible wavelengths, a Hartmann-type wavefront sensor for the EUV and soft x-ray range was developed, being employed for beam and optics characterization of FELs, synchrotrons, High Harmonic (HHG) and plasma-based sources. By at-wavelength monitoring of the wavefront behind beamline optics, typical wavefront aberrations introduced by optics misalignment effects, such as astigmatism or coma, can be strongly reduced, leading to smaller foci and enhanced peak intensities [1]. Moreover, the evaluation software accomplishes prediction of the propagation behaviour in real-time in case of coherent sources: From the simultaneously registered intensity and phase distribution beam profiles can be computed for any location along the beam path, especially the focal plane, by Fresnel-Kirchhoff integration. The propagated profiles show an excellent agreement with directly measured data. This is of particular interest in case of very small foci and for fluctuating sources.

In order to evaluate the spatial coherence properties of FEL radiation, the Wigner distribution function (WDF) of FLASH is accessed experimentally by caustic scans [2]. Representing the Fourier transform of the mutual coherence function, the WDF includes all information on the propagation parameters of partially coherent beams which are difficult to characterize in other ways. A reconstruction algorithm produces the entire WDF by mapping the measured beam profiles into a four-dimensional phase space. As a result, the global degree of coherence is determined. Results of four-dimensional WDF measurements are presented and discussed in comparison to alternate techniques, as e.g. Young´s double pin-hole experiments.

1. B. Keitel, E. Plönjes, S. Kreis, M. Kuhlmann, K. Tiedtke, T. Mey, B. Schäfer, K. Mann: „Hartmann wavefront sensors and their application at FLASH“, J. Synchrotron Rad. 23, 43–49 (2016)
2. T. Mey, B. Schäfer, K. Mann, B. Keitel, M. Kuhlmann, E. Plönjes, „Wigner distribution measurements of the spatial coherence properties of the free-electron laser FLASH“, Optics Express 22, No. 13, 16571, (2014) http://dx.doi.org/10.1364/OE.22.016571