Phase Contrast Tomography with X-ray Hartmann wavefront sensor

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The Hartmann wavefront sensor is able to measure, separately and in absolute, the real δ and imaginary part β of the X-ray refractive index [1]. While combined with tomographic setup, Hartman sensor opens many interesting opportunities behind the direct measurement of the material density. In order to handle the different ways of using an X-ray wavefront sensor in imaging, we developed 3D wave propagation model based on Fresnel propagator. The model is made in a way to manage any degree of spatial coherence of the source (Fig.1), thus enabling to model accurately experiments using tabletop source, high harmonic generation, plasma-based soft X-ray laser, synchrotron or X-ray free-electron laser. Beam divergence is described in a physical manner consistent with the spatial coherence.

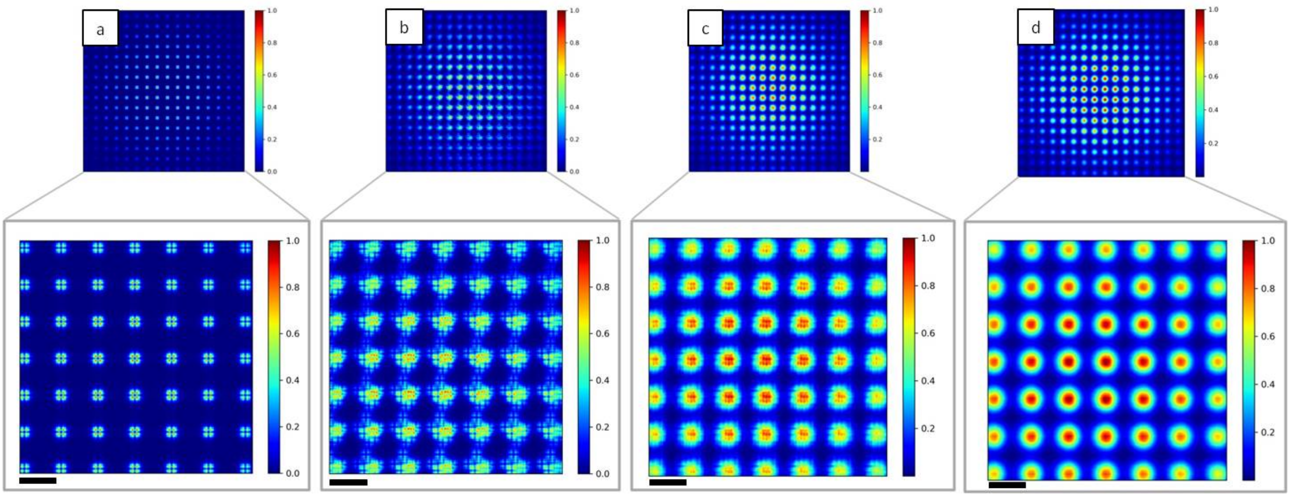

Fig.1: Examples of 2D intensity maps of the simulated Hartmann mask imaged at the detector plane for different degree of source coherence. The diffraction pattern created with coherent illumination (**a**) will become noisier decreasing the degree of coherence (**b**,**c**), reaching a Gaussian shape in the incoherent case (**d**). The Hartmann mask was designed with 8 µm pitch. The incident energy is set at 9 keV .The distance source-mask is z1=5cm and the distance mask-detector is z2=1 cm.

The capabilities of the Hartmann wavefront sensor will be compared with experimental results from in-line X-ray Phase Contrast Tomography.

[1] O. de L. Rochefoucauld *et al.*, 'Hartmann wavefront sensor in the EUV and hard X-ray range for source metrology and beamline optimization (Conference Presentation)', in *Relativistic Plasma Waves and Particle Beams as Coherent and Incoherent Radiation Sources III*, May 2019, vol. 11036, p. 110360P, doi: 10.1117/12.2522521.