Last improvments in subnanometric wavefront sensing

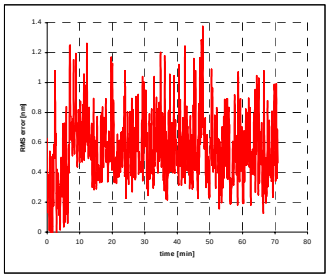
Imagine Optic
18 rue Charles de Gaulle
91400 Orsay - France

S. Bucourt , X. Levecq, J. Floriot, M.Idir, P; Mercère, P. Zeitoun

Subnanometric wavefront sensing in the visible range

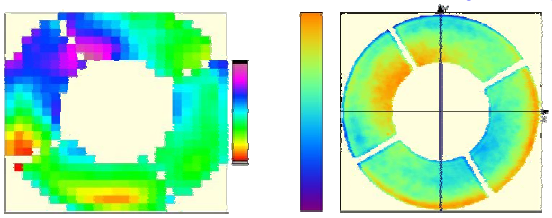
Design of High Accuracy wavefront sensor: HP26

- 26 x 26 sub-apertures (450µm pitch)
- Working wavelength: 405 nm
- Rotated-square technology®
- Accuracy: 0.7nm rms (measured)
- Repeatability: 0.24nm rms
- Thermally, mechanically and optically optimized



Repeatability: 0.24nm rms

Comparison with Fizeau interferometer for a Schwarzschild objective alignment

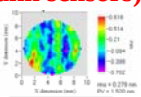


Made with HP26
PV: 28.1 nm
RMS: 5 nm

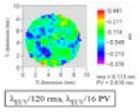
Made with interferometer
PV: 39.7 nm
RMS: 5.4 nm

Wavefront sensing in the X\EUV range (Hartmann sensors)

EUV wavelengths: 7-25nm



Absolute measurement

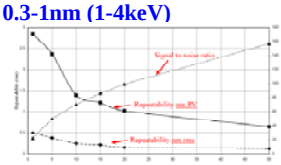


Relative measurement

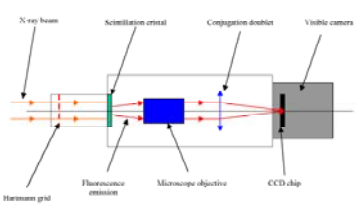
- ➔Calibration with a 0.6µm pinhole; Repeatability of λ/120 rms at 13.4nm
- ➔Achromaticity between 7 and 25nm

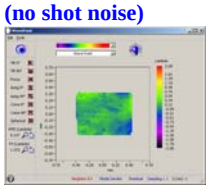
''Hartmann wavefront measurement at 13.4nm with λ_{EUV}/120 rms accuracy '', P. Mercère and al., Opt. Lett., 28, 17, (2003)

Soft X-ray range (direct detection): 0.3-1nm (1-4keV)

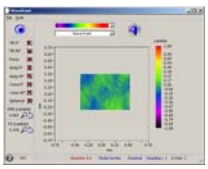


Hard X-ray range (8-12keV): indirect detection (no shot noise)





Absolute measurement

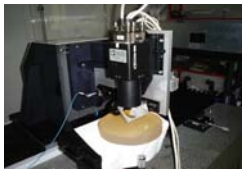


Relative measurement

Preliminary performances:

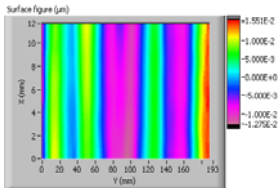
- Accuracy: 0.2nm
- Repeatability: 0.004nm rms

Subnanometric surface metrology (Shack-Hartmann Long-Trace Profilometer)



Stitching Algorithm

- Principle: multi-aperture measurement with overlapping adjacent zones
- Compensation of tanslation defects (tilts and defocus) by fitting optimization on overlapping zones
- The compensated zones are stitched together to reconstruct the surface

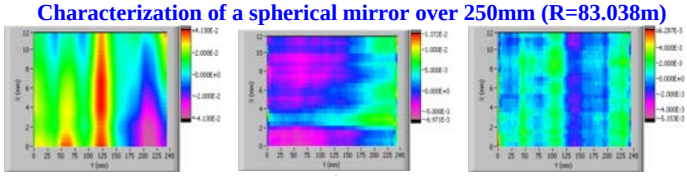


Characterization of a super-flat mirror over 190mm:

Surface: 28nm PV; 6.9nm RMS

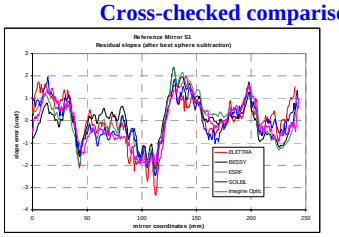
Slopes: 13.4µrad PV; 0.61µrad RMS

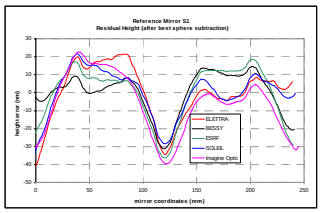
Characterization of a spherical mirror over 250mm (R=83.038m)



Surface:	X slopes:	Y slopes:
83nm PV; 17nm RMS	21µrad PV; 3.1µrad RMS	11µrad PV; 1.2µrad RMS

Cross-checked comparisons with standard LTPs



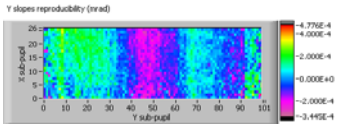


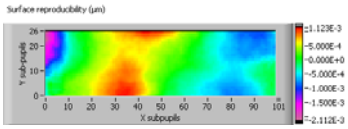
Reproducibility on slopes:

0.4µrad PV; 0.10µrad RMS

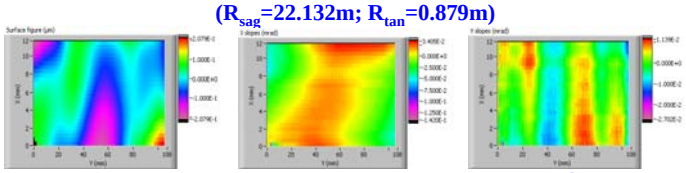
Reproducibility on surface:

3.5nm PV; 0.5nm RMS





Characterization of a toroidal X-ray mirror over 110mm (R_{sag}=22.132m; R_{tan}=0.879m)



Surface:	X slopes:	Y slopes:
416nm PV; 75nm RMS	176µrad PV; 19µrad RMS	38.5µrad PV; 5.7µrad RMS

Perspectives

SH-LTP:

- Alternative stitching algorithm
- Increasing the curvature dynamic range for synchrotron applications

X\EUV range:

- Optimization of indirect detection design
- Calibration procedure for reaching 0.02nm wavefront accuracy at 0.1nm