Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
INFN Istituto Nazionale di Fisica Nucleare

Hands-on Session: Examples of wavefront decomposition and curvature calculation from real measurements

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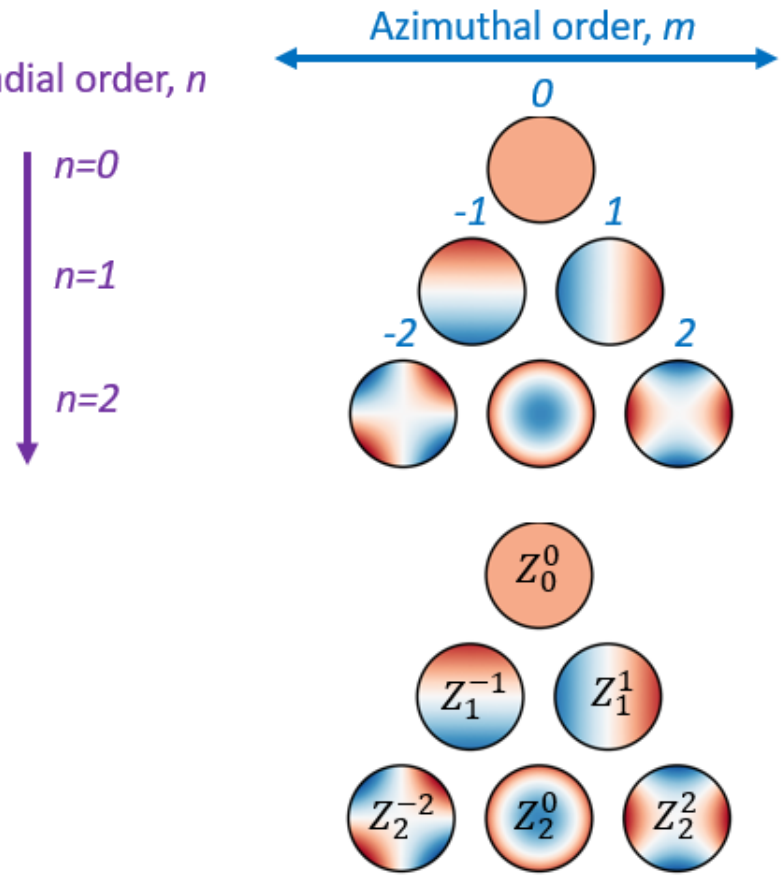
Zernike polynomials

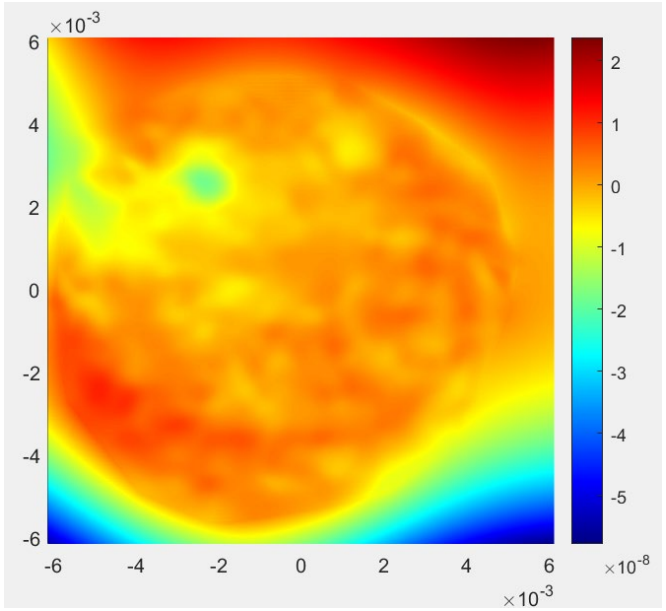
j	n	m	Z_n^m	Meaning
0	0	0	Z_0^0	Piston (constant term)
1	1	-1	Z_1^{-1}	Tilt in y-direction
2	1	1	Z_1^1	Tilt in x-direction
3	2	-2	Z_2^{-2}	Astigmatism with axis $\pm 45°$
4	2	0	Z_2^0	Field curvature, defocus
5	2	2	Z_2^2	Astigmatism with axis at 0° or 90°



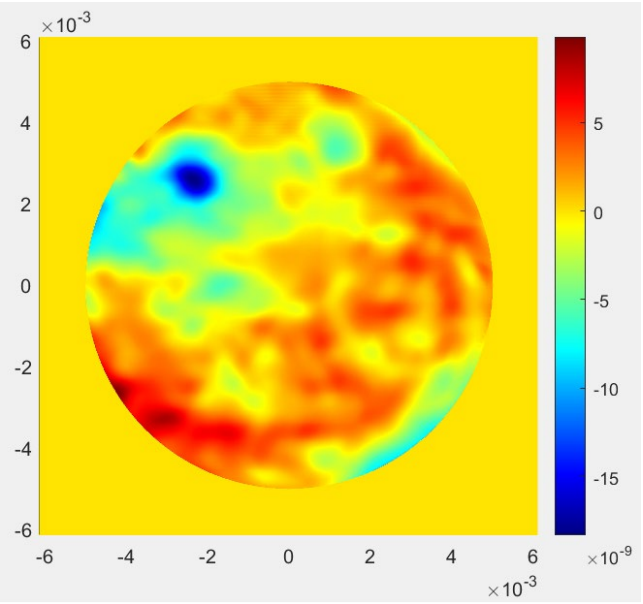
Zernike polynomials and subtraction

1) Zernike polynomials decomposition of the WF
2) 2D polynomial fit with
$y(r) = a \cdot r^2 + b \cdot x + c \cdot y + d$

Original WF



Piston, Tilt X, Tilt Y, Curv subtracted

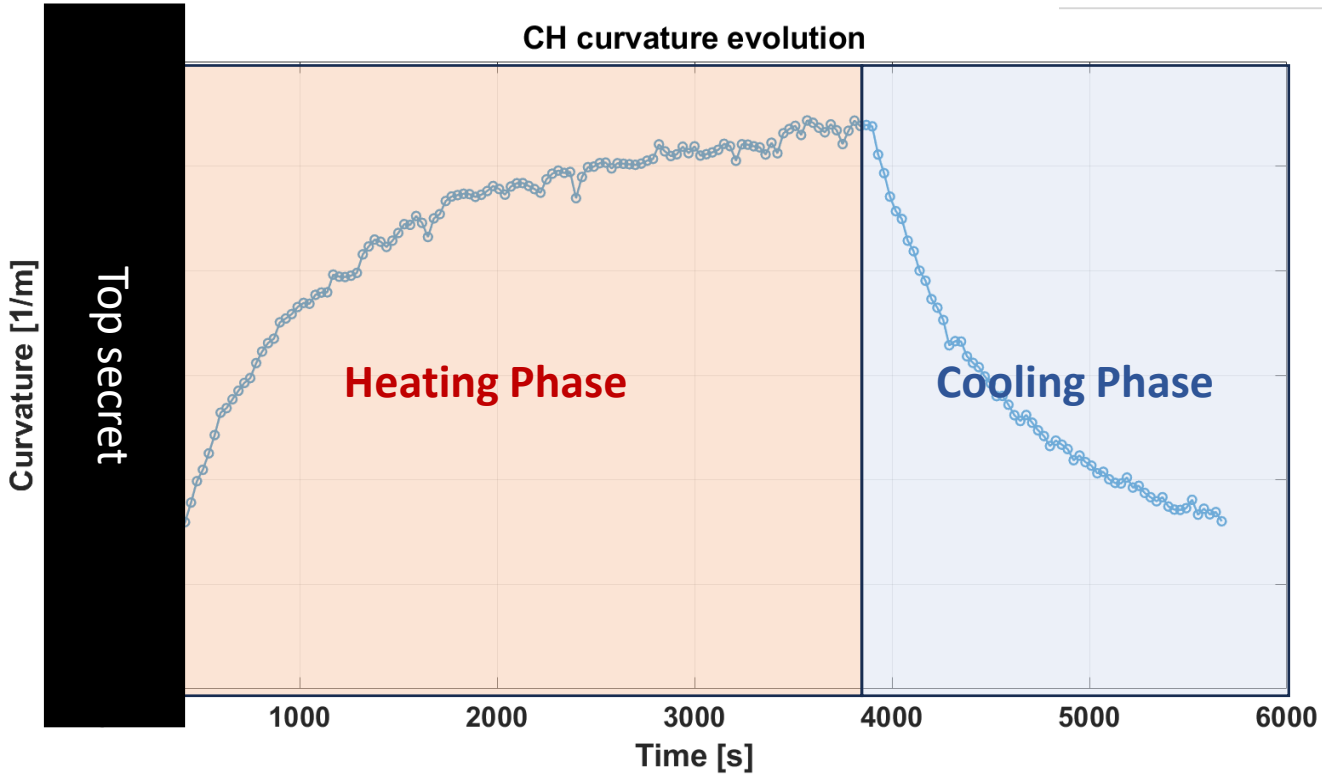


Measure parameters

AdV-TCS (CO2 laser projector)

lorenzini, nardecchia, menzione - 18:36 Wednesday 22 February 2023 (58989)

NI CH, DAS and RH alignment checks--measurements and results



Goal of the measurements: Alignment checks
total WF: 190
Time sleep: 30 s
CH power injected: 120mW

How to perform an HWS measurement:
- dark WF
- Reference WF
- Live WFs with a determined sleep time

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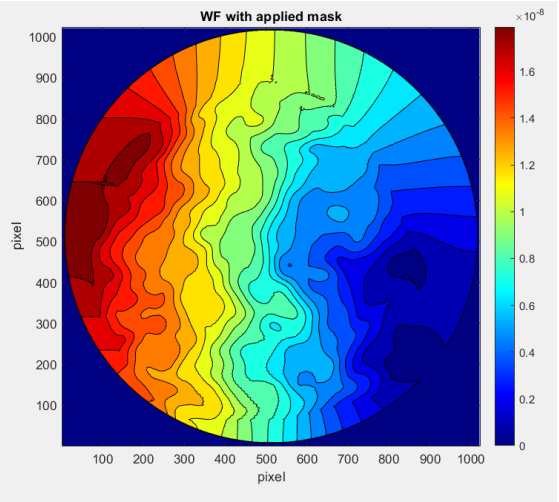
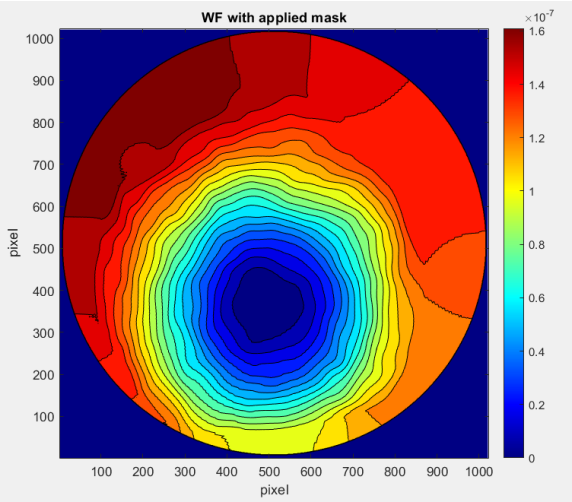
Goal of the session:

1. **WF analysis with Zernike polynomials decomposition**
2. **Extraction of the Curvature coefficient**
3. **Computation of the tau value**





All the material is collected at the link

$$y(x) = a \cdot \exp\left(-\frac{x - x_0}{\tau}\right) + c$$

plot Time vs Curvature
MATLAB: Curve Fitting
EXCEL

If we have time:
Gaussian weighted RMS and determination of center coordinates

MATLAB script:
WF_analysis_Zernike_HANDSON.m
Data folder:
wavefront

Gaussian Weighted RMS

Used to quantify the deviation from an ideal wavefront surface

$$RMS = \sqrt{\sigma_g^2} = \sqrt{\frac{\sum_{m.n} G(x_m, y_m)\left[h(x_m, y_m) - h_g\right]^2}{\sum_{m.n} G(x_m, y_m)}}$$

Wavefront distortion

ITF normalized beam intensity

$$G(x_m, y_m) = \frac{2}{\pi w_{YAG}^2}\, e^{-2(x_m^2 + y_m^2)/w_{YAG}^2}$$

$$h_g = \frac{\sum_{m,n} G(x_m, y_m)\, h(x_m, y_m)}{\sum_{m,n} G(x_m, y_m)}$$