**Model-based calibration of an adaptive interferometric setup**

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### Introduction

The measurement of aspheres and freeform surfaces is one of the main challenges in optical production control. Interferometry can provide highest accuracy at specular surfaces. To measure aspherical lenses, it is necessary to adapt fully or partially the wavefront to the surface under test.

Recently, we have proposed a non-null interferometric setup with two diffractive elements for this purpose (DGaO, A23, 2014). By shifting these two elements in both lateral directions, we achieve a variable defocus and astigmatism. The challenge of coherent stray light has been addressed in DGaO 2014. Here we focus on calibration of this adaption setup.

### Experimental setup

**Fizeau-Interferometer with adaptive optics**

![Diagram of Fizeau-Interferometer with adaptive optics](image)

**Principle of Lohmann [1]**

\[
\Phi(x, y)_{\pm} = \pm a \left( \frac{x^2}{3} + xy^2 \right) \pm bx^2 \pm dx + cy
\]

Defocus by shifting one element:

\[
\Phi_+(x, y) + \Phi_-(x + 2\Delta_x, y) = -2a\Delta_x \cdot (x^2 + y^2) - \text{tilt}(a, b, \Delta_x) \cdot x + \text{offset}(\Delta_x)
\]

Astigmatism by shifting one element:

\[
\Phi_+(x, y) + \Phi_-(x, y + 2\Delta_y) = -4a\Delta_y \cdot xy
\]

**Lohmann phases:**

\[
W_0(X, Y) = \sum_i q_i Z_i(X, Y)
\]

\[
W_p(x, y, m, n) = \sum_{i,j} p_{ij} Z_i(m, n) Z_j(x, y)
\]

The wavefronts of the light source and every pixel are described by different sets of Zernike polynomials for Q and P.

### Model for black-box calibration

For the calibration, the system is split in two black-boxes [2].

The first black-box describes the illumination part from the light source to the test area (Q), the second one the projection part from the fourier plane of the test area (P) to the camera.

**Simplified parts of the system**

![Diagram of simplified parts of the system](image)

**Calibration procedure**

1. Measurement of known spheres with different radii (r) at different positions (cxyz)

2. Simulation of all total optical paths by raytracing through the system with Q and P determined by Zemax

3. Variation of Q, P, cxyz until the difference between measured and simulated OPLs are minimal for all positions and radii

4. Variation of Q, P and cxyz until all interferograms are equal.

This results in a calibration-matrix A, which is used for measurement.

### Simulation of calibration

1. Setup at one position for phase plates

   \[ \Delta_{x,y} = \text{const.} \]

2. Interferogram of sphere in one exemplary position

3. Perturbation of the System in Zemax

4. Interferogram of sphere in the same position

**References**


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