# Measurements by ESPI of surface deformations of a heated mirror and comparison with multiphysics simulations

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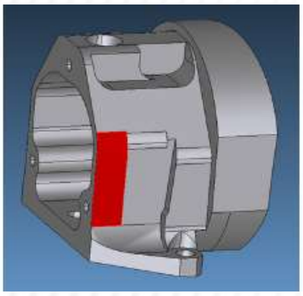
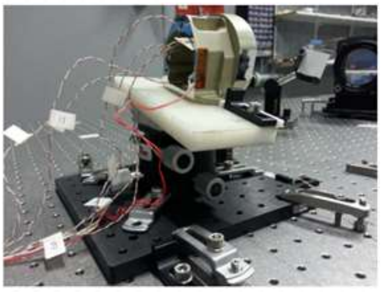


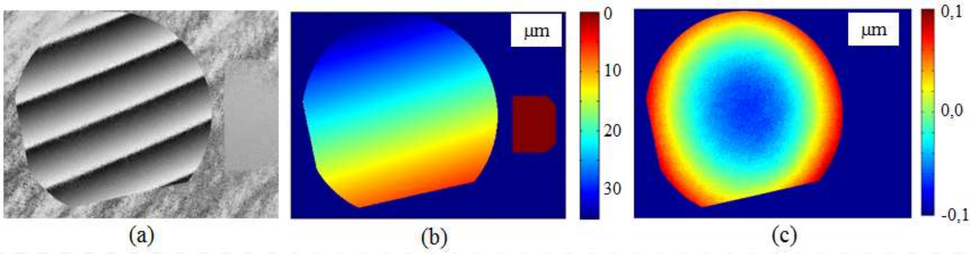


## Introduction

We present experimental results of deformation measurements of a mirror surface heated with thermal resistor and compare these results with numerical model (finite element analysis). Mirror displacements have been measured by electronic speckle pattern interferometry (ESPI) and the deformation have been deduced by subtracting rigid body motion (RBM) from the measured displacements.

The object investigated is a 80 mm diameter off-axis parabolic mirror, monolithic and made off aluminum manufactured by AMOS. This mirror is heated by a flexible thermal resistance from Minco, placed on the side of the monolithic structure, in the back position.

## Measurement of the deformations




Results for a heat power of 0.5 watts. (a) Phase measurement. (b) Mirror displacements. (c) Mirror deformation after RBM subtraction.

| | Δx | Δy | Δz | Rx | Ry | Rz |
|---|---|---|---|---|---|---|
| 0.5 watts | 4.4 µm | 4.3 µm | 2.6 µm | 0.93' | < 0.2" | 15.1" |
| 2.0 watts | 13.2 µm | 12.9 µm | 7.8 µm | 1.15' | < 0.2" | 52.6" |

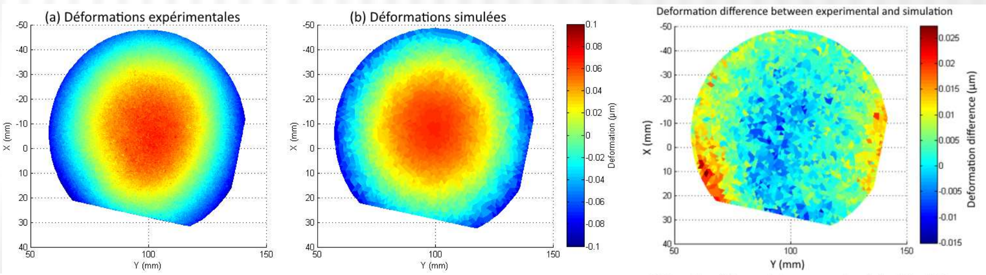
Rigid body motion values obtained by simulation for *x*, *y* and *z* translations (*Δx*, *Δy* and *Δz*), and measured experimentally for rotation round x, y and z axis (*Rx*, *Ry* and *Rz*)

ESPI measurements do not correspond only to the deformations value, but also rigid body motions (RBM). The difficulty we face is the determination of RBM – which are 3D displacements – on the basis of 2D information: we measure the displacement of the mirror surface and not a volume. Several fits have been investigated, and we selected the fit that minimizes the value of the accuracy.

We compare the numerical simulation realized with the software OOFELIE::Multiphysics to the experimental results and look at the difference between the two:

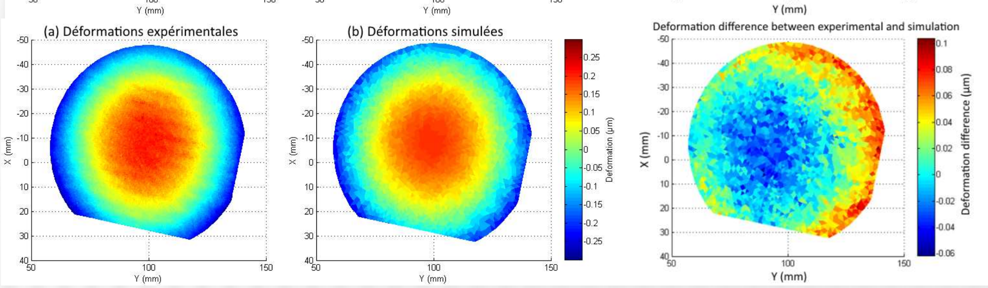
### *Results at 0.5 watts*

We found a maximal error of 27 nm and a RMS error of 6.5 nm i.e. 4% of the peak-to valley deformation.




### *Results at 2 watts*

The amplitude of deformation is about 0.5 µm and the maximum difference between the experiment and simulation is about 100 nm and the RMS error is 29.4 nm (4.9% of the peak-to-valley deformation).




## Conclusions

The measurements are consistent with the simulations despites the small deformation amplitudes. This means that the temperature variations match, and that, after RBM removal, the RMS error is smaller than 5% of the peak-to-valley deformation.

This study opens the doors to the investigation of full optical system like three-mirror anastigmat telescope which requires not only simulating the behavior of the mirror surface but requires simulating the whole system.

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