Actively Flattening a Biased MDM

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Revision: 1/12/09

In this application note, we present results of an experiment designed to determine how flat we can make a typical membrane deformable mirrors (MDM). To determine this, we actively flattened a biased MDM by using metric adaptive optics and manually adjusting actuator voltages. To quantify our success, we compensated beam divergence due to biasing, then observed root-mean-square wavefront error (RMS WFE) using a Shack-Hartmann wavefront sensor (WFS). The lowest RMS WFE we observed was 50 nm.

Optical Set-Up

To actively flatten a MDM, we closed an adaptive optics (AO) loop around it. To achieve this, as shown in Figure 1, our optical configuration included the MDM, a Shack-Hartmann WFS, a HeNe laser, and 4 reimaging lenses. The lenses in the Shack-Hartmann wavefront sensor were 150 microns in diameter and had a 6.7-mm focal length. The imaging telescope between the WFS and the DM had a 6.67x magnification. We used a software aperture to limit the analysis to an 18-mm diameter circle.

In our set-up (Figure 1), the size of a collimated beam from the laser was expanded to the diameter of the MDM by a pair of lenses. The beam was then reflected off the MDM, and its size was reduced to the diameter of the WFS by a second pair of lenses. The reference wavefront

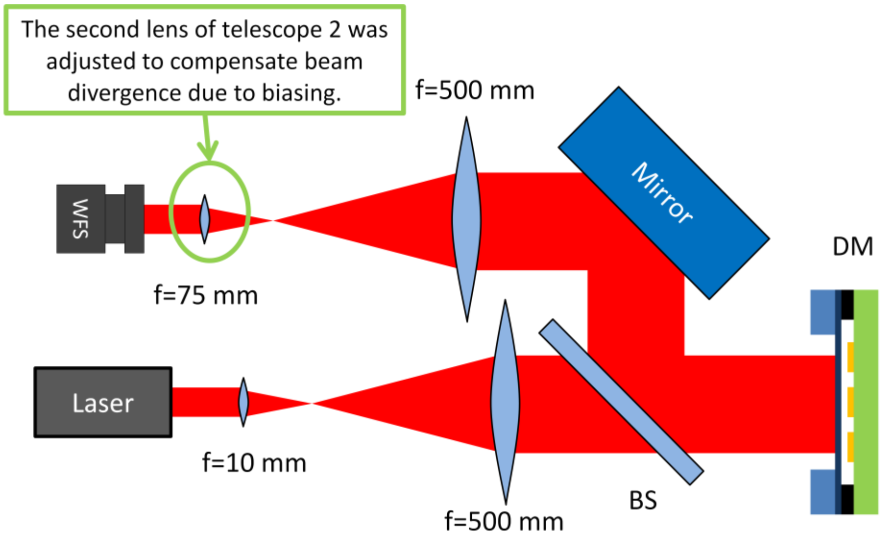

Figure 1: Optical Configuration

used in this experiment was the absolute reference obtained during calibration by shining a collimated monochromatic point source directly into the WFS.

Compensating Beam Divergence Caused by Biasing the MDM

Due to its structure function, when an MDM is biased, the mirror surface becomes concave which causes the reflected light to focus. We removed the wavefront curvature of the beam in our experiment before it reached the WFS by adjusting the position of the lens closest to the WFS, as shown in Figure 1. The adjusted lens is the second lens of a telescope, and by decreasing the length of the telescope, we added wavefront curvature to the beam, compensating curvature induced by biasing the DM.

Active Flattening

We used the AOS software to actively flatten the DM. We used metric adaptive optics to minimize the RMS wavefront slopes using the guided evolutionary simulated annealing (GESA) algorithm. After the loop converged, we manually adjusted actuator voltages to further lower RMS WFE. Our lowest achieved RMS WFE, as measured by our WFS, was 50 nm. The measured wavefront phase is shown in Figure 2. The peak-to-valley phase of the wavefront is 386 nm. It is likely that with a wavefront sensor based control and some slight adjustment to the optical system, we could achieve a better result.

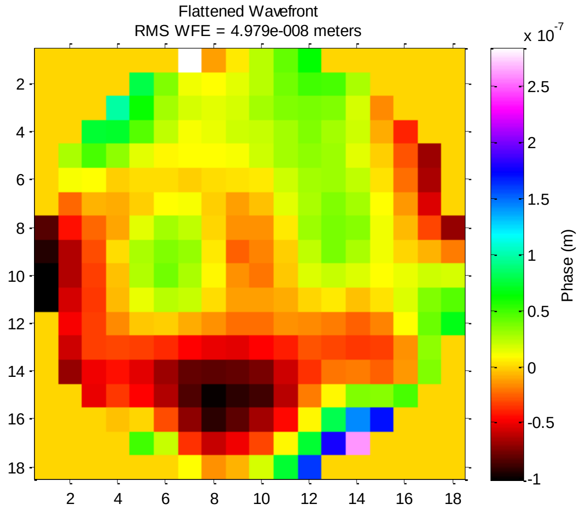

Figure 2: Flattened Wavefront