Application Note

AN006: Beam Steering

Introduction

An AgilOptics' Multi™ deformable mirror (DM) steers a focused laser beam by applying the Zernike influence functions for tip or tilt. Theoretically, the tip and tilt influence functions place no new spatial aberration within the wave front and only serve to deflect the beam on the target to a new position. Important characteristics of the deformable mirror's ability to tip and tilt a focused laser are a measure of the beam steering angular distance and the frequency response of the deformation.
Beam steering distance is measured as the angle between the lines from the center of the deformable mirror to two separate focal points.

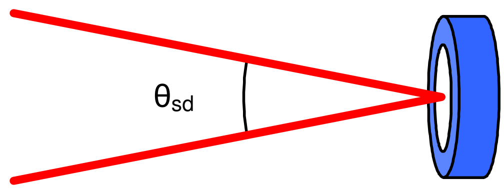

Figure 1 Steering Distance of a DM

Clarifi™ accomplishes the tip and tilt functions by measuring the beam centroid motion on a camera and using a feedback loop to walk to the beam to the desired position. A specific pixel position is input into the software that drives the DM and moves the centroid to the new position.

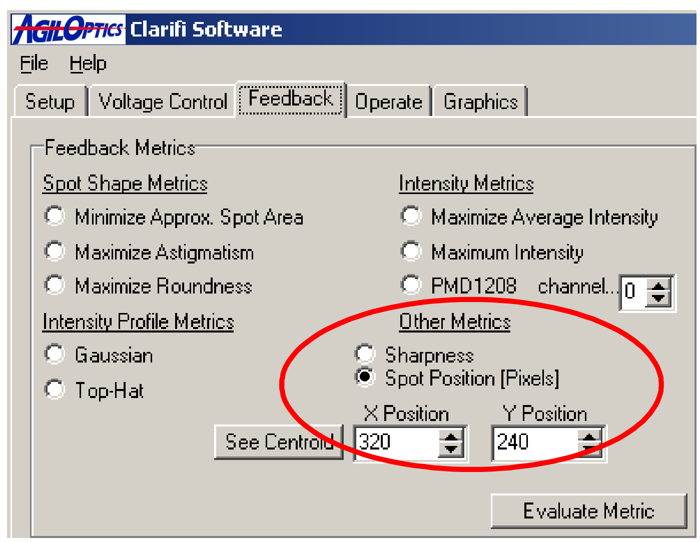

Figure 2 Spot Position Metric available in Clarifi™

The beam centroid is the center of light intensity measured by the camera. In order to maintain a centroid on the camera some focus of the beam must be maintained. This requirement is the major limiting factor in maximizing angular distance. The theoretical maximum beam steering angle is 7000 µrads. Considering that focus must be maintained, the maximum experimental beam deflection is 430 µrads.

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The tip/tilt frequency response of a deformable mirror was measured. Below is a plot of output amplitude as a function of driving frequency. The plot shows a breaking point of nearly 400 Hz. The breaking point is defined as the frequency at which the amplitude is $\frac{\sqrt{2}}{2}A_0$, where A0 is the initial output amplitude

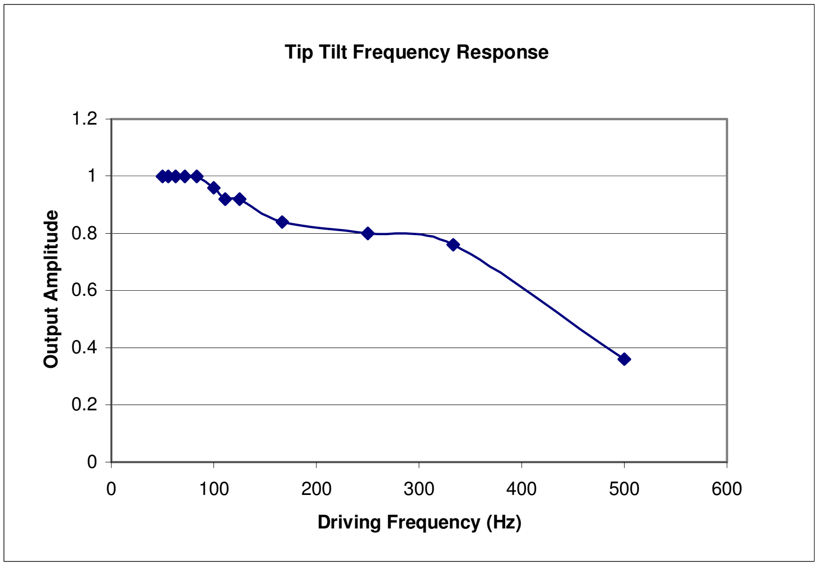

Figure 3 Tip/Tilt Frequency response

Applications of Beam Steering

Applications of beam steering are very diverse. An AgilOptics' DM provides the ability to fine-steer a laser beam within a 0.5 milliradian diameter target area, and allows the user to track the target and keep the beam accurately positioned and focused. Furthermore, an AgilOptics' DM would permit the user to control the focal spot size and shape.
A DM can switch a laser beam into a set of fibers and allows the user to choose which fiber to couple into and select the time duration of the beam switching. Controlled defocusing allows the user to set the amount of power coupled into all the separate fibers in a bundle at the same time.
Continuous movement of a laser beam can be programmed to write an alpha-numeric letter or track a moving machine a part while keeping the beam focused.
In imaging applications, an AgilOptics' DM could be used to change the area imaged into a viewing system, such as a microscope or a telescope, at a rapid rate. At each new viewing location, the system will re-focus and remove off-axis aberrations.

Demonstration Overview and Discussion

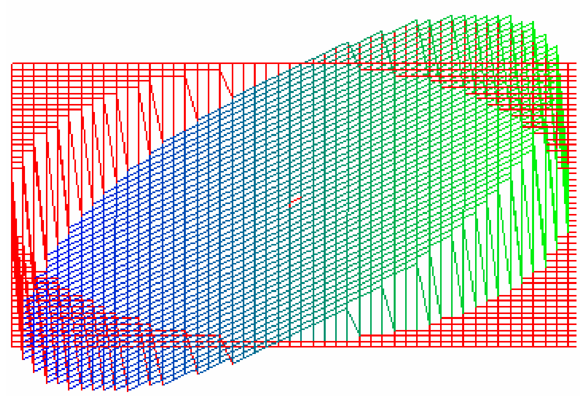

Figure 4 Zernike Tip and Tilt

Clarifi™ Basic is a closed-loop adaptive optics system sold by AgilOptics that uses a CCD camera to provide focus feedback to the software while a Multi™ mirror is being actuated to optimize the focal intensity. Clarifi™ accomplishes tip and tilt functions by measuring the beam centroid motion on the CCD camera and uses a feedback loop to walk the beam to the designated position. A desired pixel location is input into the software and voltages commands are given to the mirror that move the centroid to the new position. The beam centroid is the center of light intensity measured by the CCD. In order to maintain a centroid on the CCD some focus of the beam must be maintained. This requirement is the major limiting factor in maximizing angular distance.

Important characteristics measured during this experiment were the deformable mirror's ability to tip and tilt a focused laser, beam steering angular distance, and the frequency response of the deformation.

Figure 5 25mm Multi Deformable Mirror

Figure 5 shows the Multi mirror used for this demonstration. **Figure 6** for experimental setup.

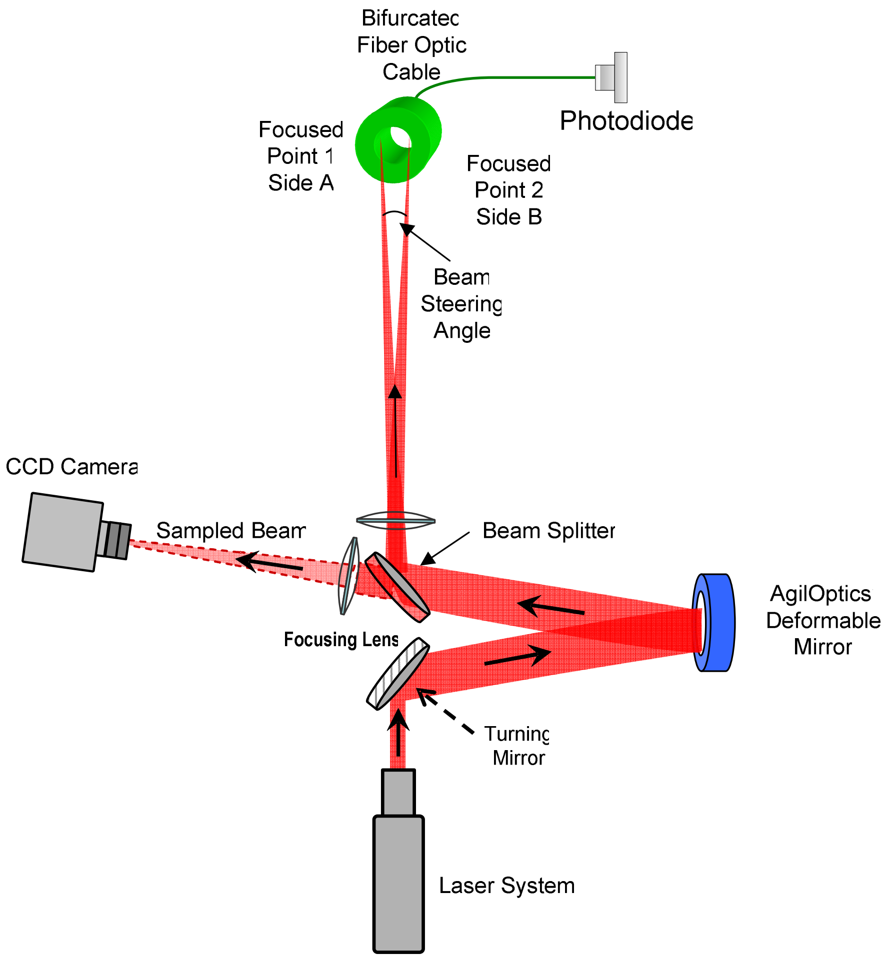

Figure 6 Beam Steering experimental Setup

Results

Clarifi™ can steer a focused laser beam into a bifurcated fiber optic with a steering range of 250µrad. Far-field focus is maintained over the range. This steering ability can be used to direct the beam between fiber bundles with potential applications for communication devices.
Mirror response is consistent up to 1000Hz. The images below show a laser steered into a bifurcated optic fiber.

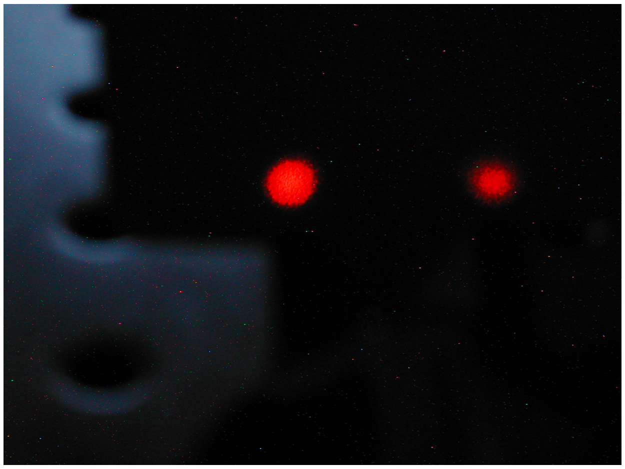

Figure 8 Laser steered to the left side of the fiber

Figure 7 Laser steered to the right side of the fiber

The two focused beams that appear on the monitor image below are actually a single beam being dithered between two points at 1000Hz.

Clarifi™ can point a laser beam, and move the focal point to various positions on command while maintaining beam focus.
A beam position can be maintained indefinitely.

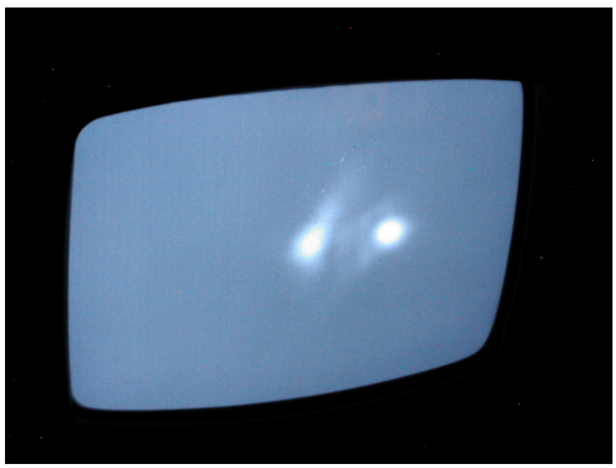

Figure 9 Monitor output from CCD camera showing steered beam

What Can Deformable Mirrors Do?

- Correct Optical Aberrations
- Laser Beam Shaping
- Optical Image Enhancement

Deformable mirrors are revolutionizing laser and optical systems by replacing static components with dynamic optics. Deformable mirrors (DM) are adaptive optics with dynamic faces able to optimize or change the characteristics of reflected light for a specific application. With time-varying control, a DM can focus a beam at several different points at different times or it can replace a lens in an optical system. Deformable Mirrors can improve optical images in telescopes, cameras, and other imaging systems.

For further information and discussion about how deformable mirrors work and how they will solve your optical problems see the manuals for HVDD, Clarifi, and the application notes available on the Web.

http://www.agiloptics.com/AppNotes.htm

http://www.agiloptics.com/downloads.htm