
A low-cost, high-speed, very high-order Shack-Hartmann sensor for testing TMT deformable mirrors

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Abstract

The Thirty Meter Telescope will use a sophisticated adaptive optics system called NFI-RAOS. This system utilizes two deformable mirrors conjugate to 0 km and 11.2 km to apply a Multi-Conjugate Adaptive Optics (MCAO) correction over a 2 arcminute field of view. DM0 and DM11 have 63 and 75 actuators across their respective diameters. To study the behavior of these mirrors, we have developed a low-cost, very high-order Shack-Hartmann Wavefront Sensor (WFS). We will use our WFS to calibrate the flatness of the DMs and measure the influence functions of the actuators. NFIRAOS is cooled to reduce the thermal emissivity of optical surfaces visible to the science detectors, so we will also measure the behaviour of the DMs in both warm and cold environments. As the cold chamber is prone to vibrations, a WFS is preferred to a phase-shifting interferometer. Our design was driven by the need to be able to evaluate the DM surface between the actuators, which led to the requirement of at least 248 sub apertures across the diameter. The largest commercially available Shack-Hartmann WFS has only 128 sub-apertures across the diameter, which is not enough to properly sample these DMs. Furthermore, the designed sensor is able to record the wavefront at 50 FPS (50 times per second) at full resolution. To fabricate this WFS, we used a commercial off-the-shelf CMOS detector, camera lens, and lens let array, which kept the total cost less than 20K USD. Here we present the design and performance characteristics of this device.

Keywords: wavefront sensing, Shack Hartmann, high order, low cost

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