Wavefront Sensor lab for High-Contrast Imaging

Mala Mateen*[1], Johanan Codona†[2], Scott Newey‡[3], Michael Hart§[2], Denis Oesch¶[4], Colton Bigler‖[5], Troy Rhoadarmer**[6], and Robert Johnson††[5]

[1]Starfire Optical Range [AFRL] – United States
[2]Hart Scientific Inc. – United States
[3]Starfire Optical Range [Boeing, AFRL] – United States
[4]Science Applications International Corporation – United States
[5]Starfire Optical Range [AFRL] – United States
[6]General Atomics - EMS – United States

Abstract

Detecting dim exoplanets close to bright stars with extremely large telescopes will require wavefront sensors that utilize the full spatial coherence of the pupil. This will allow better measurement and correction of low-order spatial modes, which diffract starlight close to the star. We present a closed loop demonstration with three different wavefront sensors: the Shack Hartmann (SHWFS), the three-sided Pyramid (3PWFS), and the non-linear Curvature Wavefront Sensor (nlCWFS), using a new wavefront sensor testbed. The testbed is equipped with a variable three-wavelength source, an atmospheric turbulence simulator (ATS), and an adaptive optics system consisting of a fast-steering mirror and a 10x10 MEMS deformable mirror. We present the ATS calibration procedure and describe the range of turbulence parameters it can model, as well as the calibration process for each of the WFSs and the development of their reconstruction algorithms. We explore the baseline linear and nonlinear response of the 3PWFS and nlCWFS as a means to extend the accuracy of wavefront estimation in a regime of high signal-to-noise ratio. Previous work by Schatz et al. (2022) demonstrated and evaluated closed-loop performance of the 3PWFS. The objective of the new work is to empirically use each of the three WFS types to close an AO loop across a range of atmospheric turbulence profiles and source brightness and to quantify the closed-loop response of each sensor.

Keywords: Pyramid wavefront sensor, non, linear curvature wavefront sensor, high, contrast imaging

*Speaker
†Corresponding author: jlcodona@hartsci.com
‡Corresponding author: scott.newey.ctr@us.af.mil
§Corresponding author: mhart@hartsci.com
¶Corresponding author: denis.oesch.ctr@us.af.mil
‖Corresponding author: colton.bigler@spaceforce.mil
**Corresponding author: Troy.Rhoadarmer@ga.com
††Corresponding author: robert.johnson.104@spaceforce.mil