
Update from the Starfire High-contrast Adaptive Optics Wfs (SHADOW) testbed

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Abstract

We present results from our on-going sensitivity analysis from high-contrast wavefront sensors. Sensitive wavefront sensors are critical to the detection of dim exoplanets close to bright stars. Wavefront sensors that can exploit the full spatial coherence of the aperture allow better measurement and correction of low-order modes, that diffract starlight close to the star. This is a $(D/r_0)^2$ gain in sensitivity and for VLTs and ELTs this translates to a D^4 gain for the lowest modes. In our high contrast testbed we compare the sensitivity of three different wavefront sensors, the Shack-Hartmann (SH), the non-linear Curvature (nlC), and the three-sided Pyramid (P), wavefront sensor. We explore how the sensitivity of each wavefront sensor, particularly to low-order modes, is affected in photon starved environments. We use reflective turbulence phase screens to introduce turbulence imprinted with Kolmogorov statistics to each of the wavefront sensors and close the loop with each wavefront sensor, in turn. The reconstructed wavefront is decomposed into Zernike modes and compared to the input aberration. A Monte Carlo statistical analysis is carried out to determine how many photons are required by each wavefront sensor to sense each mode. For the nlCWFS we compare several reconstruction methods, raw intensity, Gerchberg-Saxton, and machine learning using convolutional neural nets, to determine the most efficient reconstruction algorithm. An efficient reconstruction algorithm translates to either dimmer targets, or a faster adaptive optics bandwidth. We hope to quantitatively identify a wavefront sensor optimized for high contrast detections in low signal-to-noise regimes.

Keywords: High contrast imaging, Shack, Hartman WFS, Pyramid WFS, non, linear Curvature WFS

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