
Investigating ways to use a Non-modulated Pyramid Wavefront sensor with a Rayleigh Laser Guide Star

Benjamin L. Gerard^{*1}, Aaron J. Lemmer¹, S. Mark Ammons¹, Lisa A. Poyneer¹,
Bautista R. Fernandez¹, and Brian J. Bauman¹

¹Lawrence Livermore National Laboratory – United States

Abstract

Astronomical adaptive optics (AO) is a critical approach to enable science requiring ground-based diffraction-limited imaging. Artificial laser guide stars (LGSs) for AO have thus far only been used with a Shack Hartman Wavefront Sensor (SHWFS), but not yet with a Pyramid Wavefront Sensor (PyWFS). One of the technical challenges with PyWFS that a SHWFS does not face is using a pupil plane tip/tilt modulator to steer the PSF around the tip of the focal plane pyramidal phase mask per PyWFS frame, typically at a modulation radius of a few resolution elements. Such modulation is, however, generally necessary to provide sufficient dynamic range to close the AO loop on atmospheric turbulence. However, in this work we explore options to remove the need for a LGS PyWFS tip/tilt modulator, instead leveraging the inherent incoherent atmospheric scattering process between at uplink and downlink for LGS light. We show simulations that a custom static pupil plane phase mask for a LGS uplink can enable reaching close to the classical tip/tilt modulated PyWFS dynamic range, with more phase mask design parameter space to be explored for further dynamic range optimization. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. This document number is LLNL-ABS- 849572.

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^{*}Speaker