Experimental validation of Flip-flop modulation on the ESO GHOST

Byron Engler*†[1], Cedric Heritier[1,2], Markus Kasper[1], Paul Bristow[1], Miska Le Louarn[1], Christophe Verinaud[1], and Richard Clare[3]

[1]European Southern Observatory – Germany
[2]Laboratoire d'Astrophysique de Marseille – Aix Marseille Université, Aix Marseille Université : UMR7326 – France
[3]University of Canterbury – Christchurch, New Zealand

Abstract

The adaptive optics systems of extremely large telescopes (ELTs), such as the European Southern Observatory's ELT, will have to cope with the pupil segmentation caused by the secondary mirror support structure (spider). The pyramid wavefront sensor, which is the baseline wavefront sensor for the single conjugate adaptive optics (SCAO) mode for many instruments, has a poor sensitivity to piston errors between the pupil segments. The pyramid wavefront sensor is typically operated in one of two modes: modulated, where the telescope's focal point is modulated about the tip of the pyramid in a circular pattern, and unmodulated, where the telescope's focal point is on the tip of the pyramid. By increasing the radius of the modulation, the linearity and dynamic range of the sensor are improved, whilst the sensitivity of the sensor is degraded. Previously in simulation, we have shown that an unmodulated pyramid wavefront sensor has a significantly greater sensitivity to segment piston modes when compared to a modulated pyramid. Based on this observation, Flip-flop modulation was presented, where the pyramid is operated in modulated (70% duty cycle), and unmodulated (10% duty cycle) modes and the remaining 20% is used to switch between the states. This paper details the experimental validation of Flip-flop modulation on the GPU-based High-order adaptive OpticS Testbench (GHOST) at ESO and the characterisation of the modulation mirror to fine-tune and verify the modulation path. Using the spatial light modulator of the GHOST, arbitrary pupil/spider geometries are emulated, with an adjustable segment piston, allowing the performance of Flip-flop modulation to be characterised under various conditions.

Keywords: pyramid, flipflop, petal, petalometer, elt

*Speaker
†Corresponding author: byron.engler@eso.org