Impact of DM misregistration for NCPA compensation in HARMONI's SCAO system

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Abstract

HARMONI is the first light visible and near-IR integral field spectrograph for the ELT. It covers a large spectral range from 450 nm to 2450 nm with resolving powers from 3500 to 18000 and spatial sampling from 60 mas to 4 mas. It can operate in two Adaptive Optics modes – SCAO (including a High Contrast capability) and LTAO – or with NOAO. The project is preparing for Final Design Reviews.
Wavefront sensing for the SCAO mode is provided by the SCAOS subsystem, mainly by a Pyramid WaveFront Sensor (PyWFS). The high sensitivity of the PyWFS comes at the expense of a small dynamic range, limiting its ability to compensate for Non-Common Path Aberrations (NCPAs) through offsets of the operating point (i.e. using reference slopes). As NCPA compensation is crucial for good image quality, especially for high contrast operations, a low-order loop upstream of the PyWFS will be implemented to correct for NCPAs. This loop consists of a Shack-Hartman WFS (BlueSH) controlling a Low-Order DM (LODM). The reference slopes of the BlueSH will be modified so that the LODM absorbs large low-order NCPAs and delivers a flat wavefront to the PyWFS.
A Calibration DM (CalDM) will be used to calibrate NCPAs and determine the BlueSH's reference slopes. However, constraints in the optical design requires the LODM to be rotated with respect to the CalDM, and places them several metres apart, leading to misregistations. In this paper, we present the results of Monte Carlo simulations of the CalDM-LODM system to determine how residual WaveFront Errors (WFEs) between the DMs vary with these misregistrations. We find residual WFEs to be $\leq 3\%$ for all rotation angles and pupil shifts ≤ 0.5 a DM pitch (5% of the pupil) when controlling the first 50 Zernike modes. Small magnification errors contribute little to overall error. This result confirms the LODM can deliver a flat wavefront to the PyWFS even with large misregistrations.

Keywords: deformable mirror, NCPA, SCAO

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