ZELDA WFS for the ELT-HARMONI high-contrast module - Calibration of the sensor under realistic observation conditions

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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 450nm to 2450nm with resolving powers from 3500 to 18000 and spatial sampling from 60mas to 4mas. It can operate in two Adaptive Optics modes - SCAO (including a High Contrast capability) and LTAO - or with NOAO.
The High Contrast Module (HCM) will allow HARMONI to perform direct imaging and spectral analysis of exoplanets up to 10 times fainter than their host star. Quasi-static aberrations are a limiting factor and must be calibrated as close as possible to the focal plane masks to reach the specified contrast. A Zernike sensor for Extremely Low-level Differential Aberrations (ZELDA) will be used in real-time and closed-loop operation at 0.1Hz frequency for this purpose. Unlike a Shack-Hartmann, the ZELDA wavefront sensor is sensitive to Island and low-wind effects. The ZELDA sensor has already been tested on VLT/SPHERE and will be used in other instruments. Our objective is to adapt this sensor to the specific case of HARMONI.
A ZELDA prototype is being both simulated and experimentally tested at IPAG. Its nanometric precision has first been checked during 2020 in the case of slowly evolving, small wavefront errors, and without dispersion nor turbulence residuals. On this experimental basis, we address the performance of the sensor under realistic operational conditions including residuals, mis-centring, dispersion, sensitivity, etc. Atmospheric refraction residuals were introduced by the use of an Atmospheric Dispersion Corrector, and turbulence was introduced by a Spatial Light Modulator which is also used to minimise wavefront residuals in a closed loop in the observing conditions expected with HARMONI.

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