# A Zernike wavefront sensor for the ELT-HARMONI high-contrast module - Results from a testbench under realistic observation conditions

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**Abstract**

HARMONI is the near-infrared integral field spectrograph of ESO's Extremely Large Telescope (ELT). Its High Contrast Module (HCM) operating in close relation to the single conjugate adaptive optics subsystem will allow HARMONI to perform direct imaging and spectral analysis of exoplanets as close as 50 mas to their host star and up to 10 times fainter, in the 1.25-2.45$\mu$m spectral range.
Quasi-static aberrations will set the detection limit of the high contrast imaging system. Measuring and compensating these residual aberrations, as close as possible to the focal plane mask that will block the star light and at near-infrared wavelength of 1.2$\mu$m, is therefore one of the conditions for reaching the desired 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 sensor, the ZELDA sensor measures phase directly and will therefore be sensitive to island and low-wind effects. In addition, the ZELDA sensor is a pupil plane sensor and can be used to accurately measure the position of the pupil, which is important for system alignment.
A ZELDA prototype is being 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. Atmospheric refraction residuals and Adaptive Optics residuals were introduced in 2021, allowing its range and robustness to be checked. A spatial light modulator is used to minimise wavefront residuals in a closed loop in the observing conditions expected with HARMONI: firstly without atmospheric dispersion or AO residuals, then with atmospheric dispersion only. Tests with AO residuals are currently tested and the case with both effects will soon be tested.

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