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Correction of NCPAs using a deformable lens in pyramid wavefront sensor-based AO systems: preliminary lab results

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Summary

Pyramid wavefront sensors are widely used in adaptive optics systems, and in particular in extreme adaptive optics applications, due to their advantages in terms of sensitivity with respect to other wavefront sensors such as Shack-Hartmann. In particular, as it is well-known, when the adaptive optics loop is closing, the reference star image size gets smaller on the pyramid tip, providing increased sensitivity. However, NCPAs (due to the different optical elements in the wavefront sensor and scientific arms) cause image distortions that can hinder the scientific throughput. NCPAs are usually corrected introducing offsets on the pyramid closed-loop control systems, but the consequent increase in size of the star image on the pyramid tip, leads to a decrease in sensitivity that compromises the aforementioned advantages.
A test-bench has been realized realized at CNR-IFN Institute in Padova, with the collaboration of INAF-Padova, aiming NCPAs correction inserting a multi-actuator deformable lens in the sensing path, in order to recover the optimal working conditions and the ideal magnitude gain of the pyramid. The adaptive lens is composed by two thin glass plates bonded to two piezoelectric rings with multiple actuators and the actuation of the lens allows a wavefront modulation up to the 4th order of Zernike polynomials with a relatively fast time response (frequency up to 500Hz). In particular, we present the laboratory results to show the correction of NCPAs when inserting and driving the multi-actuator deformable lens in the sensing arm, while the main adaptive optics loop is working, thus maximizing the scientific image sharpness. The use of this lens avoids changes in the optical configuration, providing a simple, yet effective way, to correct for NCPAs in existing instruments.

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