End-to-end numerical simulations of SAXO+, a two-stage AO system for high-contrast imaging

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Abstract

SAXO+ is the upgrade of SAXO, the adaptive optics system of SPHERE at the ESO's Very Large Telescope. The current system, SAXO, includes a visible Shack-Hartmann wavefront sensor. SAXO+ consists of a second stage adaptive optics downstream the SAXO stage and features a pyramid wavefront sensor. The pyramid bandwidth is near-infrared to look at fainter and redder stars.
In this work, we use end-to-end numerical simulations to evaluate the improved performance of SAXO+ compared to SAXO and optimize key system parameters. We estimate the pyramid optical gains under various seeing conditions and star magnitudes. We assess the impact of compensating non-common path aberrations with the pyramid wavefront sensor. The adaptive optics performance criterion is the starlight residual intensity in the perfect coronagraph image : the lower the better.
SAXO+ improves the performance of the system by a factor of 10 compared to SAXO, inside the second stage correction zone. A 2 λ / D modulation radius for the pyramid wavefront sensor is a safe trade-off between performance and robustness against varying turbulence conditions. Under usual observing conditions, the compensation of non-common path aberrations with the pyramid wavefront sensor does not significantly impact the SAXO+ performance. This result is consistent with the estimation of the optical gains, which are between 0.8 and 1 for standard observing conditions.

Keywords: high, contrast imaging, SPHERE, second, stage AO, pyramid WFS, optical gains, NCPA

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