Science test cases benchmark simulations of the SPHERE XAO system towards SPHERE+ high contrast performances

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Abstract

The Spectro-Polarimetric High-contrast Exoplanet REsearch instrument (SPHERE) is a European Southern Observatory exo-planet imaging instrument installed on the 8m Very Large Telescope at Paranal (Chile). It has been operating for over 8 years since its commissioning in 2014. The SPHERE+ project proposes an upgrade of this existing system to expand its science objectives. In particular, the current XAO system (SAXO) main update will consist in the addition of a second stage of correction using a pyramid wavefront sensor operating at near infrared wavelengths. The second stage will take advantage of the fact that the residual phase of the first stage will be already partially corrected and will run at a nominal frequency three times faster than the existing XAO system. As a part of the design process for this new XAO system, we performed E2E XAO simulations using both COMPASS and PAOLA. The numerical simulations are essential in the first place

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to determine the optimal design for the hardware configurations and the controllers of the considered high contrast instruments and then to estimate their corresponding performance. After refining the current SAXO system parameters we validated its simulated performances (Strehl, PSF profile, contrast) by comparing them to a large selection of on sky data both with and without coronagraph at wavelengths ranging from 0.7 to 2.3 microns. This SAXO study increases the reliability of our E2E models and thus mitigates the risk of incorporating a second stage system onto SAXO. Using the same science cases we perform SAXO+ E2E and analytical simulations including coronagraph, which we will also describe in this presentation. Such well-calibrated benchmark study under identical boundary and parameter conditions provides quantitative comparison of the strengths and weaknesses of the different control methods. Beyond SPHERE+, this is also important for the future high contrast instruments.

Keywords: SPHERE+, PCS pathfinder, High contrast, XAO