SAXO+ upgrade : second-stage AO system end-to-end numerical simulations

Charles Goulas*†[1], Fabrice Vidal[1], Raphael Galicher[1], Johan Mazoyer[1], Florian Ferreira[1], Arnaud Sevin[1], Anthony Boccaletti[1], Clémentine Béchet[2], Michel Tallon[2], Maud Langlois[2], Gaël Chauvin[3], Julien Milli[3], and Eric Gendron[1]

[1]LESIA – Observatoire de Paris-Université PSL, Centre National de la Recherche Scientifique - CNRS, Sorbonne University, Université Paris Cité – France

[2]Centre de Recherche Astrophysique de Lyon – École Normale Supérieure - Lyon, Université Claude Bernard Lyon 1, Institut National des Sciences de l'Univers, Centre National de la Recherche Scientifique, Institut national des sciences de lÚnivers – France

[3]Institut de Planétologie et d'astrophysique de Grenoble – Centre National d´tudes Spatiales [Toulouse], observatoire des sciences de l'univers de Grenoble, Centre National d´tudes Spatiales [Toulouse], Centre National d´tudes Spatiales [Toulouse], Centre National d'Études Spatiales [Toulouse] – France

Abstract

SPHERE+ is a proposed upgrade of the SPHERE instrument on the ESO's Very Large Telescope. It will improve the detection and characterization capabilities of young giant planets. It includes an additional second-stage adaptive optics (AO) system composed of a dedicated near infrared wavefront sensor (WFS) and a deformable mirror (DM). This second stage will remove the residual wavefront errors left by the actual primary AO loop (SAXO). This paper is focused on the numerical simulations of the second stage (SAXO+) and concludes on the impact of the main AO parameters used to build the design strategy.
To run these simulations we use COMPASS, an end-to-end AO simulation tool. COMPASS was modified to handle the temporal asynchronism of the two stages. It was also improved to simulate the hybrid wavefront sensing capabilities, namely a Shack-Hartmann for the first stage and a pyramid for the second one. A dedicated coronagraph module was implemented in order to produce coronagraphic images and quantify the system performances with contrast ratios.

We present the simulation results in terms of raw contrast curves and compare them to the actual SAXO system. The explored parameter space includes turbulence conditions, star magnitudes and SAXO+ relevant design parameters. The key system choices addressed in these results are the AO control strategy (integrated or stand alone solution), the RTC frequency, the DM choice, WFS calibration parameters, and photon sharing. We show an improvement of a factor 10 in raw contrast compared to the current system.
In the future, a focal plane wavefront control loop will be added to the simulation to minimize the speckles intensities on the coronagraphic images.

Keywords: SPHERE, extreme AO, multi stage AO, high contrast imaging, numerical simulations

*Speaker
†Corresponding author: charles.goulas@obspm.fr