The PACOME algorithm: Multi-epoch combination of direct imaging observations for exoplanet detection

Jules Dallant*†[1], Maud Langlois‡[1], Olivier Flasseur§[1], and Eric Thiébaut¶[1]

[1]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

Abstract

Direct imaging exoplanet detection and characterization require combining extreme adaptive optics with custom differential imaging and dedicated post-processing algorithms to eliminate the residual stellar leakages.

Over the last decade, large efforts have been invested on new powerful post-processing algorithms. They currently allow the detection of massive exoplanets down to 10 au but their performance remain limited at shorter angular separations due to the lack of diversity induced by the processing of each epoch of observations individually.

The upcoming thirty meters class telescopes such as the ELT, will enable exploring much deeper the inner environment of nearby solar-type stars. The contrast levels to reach will require long exposure times of several tens of hours, that will only be achieved by combining several observations conducted days, weeks, or months apart. At these timescales and separations, the orbital motion of exoplanets will no longer be negligible, and a proper orbital modeling will be crucial to combine multi-epoch observations without drastically degrading the detection confidence and the achievable contrast.

Very recently, we proposed the PACOME algorithm that combines optimally several observations of the same star within an end-to-end maximum likelihood based statistical detection formalism. It accounts for the Keplerian orbital motion of the sought exoplanets across epochs and co-adds constructively their weak signals. Its sensitivity and the reliability of its astrophysical outputs (orbital elements and their uncertainties) constitute major advantages in the field to detect new companions at a statistically grounded confidence level. Besides, its implementation is efficient and fully automatized, allowing to test and refine a large number of orbits in a reasonable computation time.

Keywords: high angular resolution, image processing, detection, exoplanets, data modeling, data analysis, signal to noise ratio, maximum likelihood

*Speaker

†Corresponding author: jules.dallant@univ-lyon1.fr

‡Corresponding author: maud.langlois@univ-lyon1.fr

§Corresponding author: olivier.flasseur@univ-lyon1.fr

¶Corresponding author: eric.thiebaut@univ-lyon1.fr