PSF reconstruction from hyper-spectral AO science images - from VLT to ELT

Alexis Lau*[1], Romain Fetick[1,2], Benoit Neichel[1], Olivier Beltramo-Martin[3], and Thierry Fusco[1,2]

[1]Aix Marseille Université, CNRS, LAM – CNRS : UMR7326 – France
[2]DOTA, ONERA, Université Paris Saclay [Châtillon] – ONERA – France
[3]SpaceAble – SpaceAble – France

Abstract

Point-Spread Function (PSF) retrieval remains a key challenge in Adaptive Optics (AO) observations, and inadequate knowledge of the PSF sets a hard limit to deliver precise photometric and astrometric data, or to provide any information with a higher spatial resolution. The latter refers to deconvolution, where accurate PSF models are required to enhance low contrast features in the images. Deconvolution is highly sensitive to the input PSF and without an accurate PSF model, it is nearly impossible to perform this operation. Reference PSFs are not always available in the images, especially for observation of very crowded regions and extended sources.
Our work aims to offer an operative solution to those who may not have access to a reference PSF and wish to obtain precise photometric, astrometric and enhanced spatial resolution for science observations. We recently introduced a significant improvement to such a PSF estimation process, by making use of the whole hyperspectral data cubes like one provided by MUSE. Our approach is based on blind-deconvolution (e.g. AMIRAL algorithm), which allows to estimate the PSF directly from the science observations. By first making use of an analytical PSF model that simplifies the PSF estimation process down to a few parameters, and then taking into account the known PSF variation across wavelengths, we significantly improve the statistical contrast (ratio between the number of available data (images) and the number of unknown to estimate), and eventually demonstrate accurate and robust PSF estimation directly from the science data. The PSF information can then be used for deconvolution, enhancing low contrast features in the observations.
We illustrate our method with recent images of Ganymede and Callisto obtained with MUSE-NFM. We also show how this tool will be key for extended object observations from ELT-HARMONI.

Keywords: Deconvolution, PSF reconstruction, image processing

*Speaker