Development of PSF reconstruction for first light instruments on the ELT

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Abstract

Even though Adaptive Optics (AO) correction is used in modern instruments of ground based telescopes, the quality of astronomical images still is degraded due to the time delay stemming from the wavefront sensor (WFS) integration time and adjustment of the deformable mirror(s) (DM). This results in a blur which can be mathematically described by a convolution of the original image with the point spread function (PSF) of the instrument, telescope and residual atmospheric perturbations. The PSF of an astronomical image varies with the position in the observed field, which is a crucial aspect in observations on Extremely Large Telescopes (ELT).

We present an algorithm to reconstruct the PSF in any position in the field of view using AO telemetry data and knowledge on the atmospheric profile. Our algorithm can easily be adapted to Single Conjugate AO (SCAO) and Multi Conjugate AO (MCAO) systems. In particular, we adapt an approach for atmospheric tomography to be used with a time series of AO telemetry data in SCAO mode. As input our algorithm requires knowledge of the strength of the different turbulent atmospheric layers, their wind speeds and directions in order to perform the tomography step. To obtain the respective contribution to the PSF, we project the reconstructed layers in the direction of interest.

Our results are obtained for a simulated ELT setting in OCTOPUS, the ESO end-to-end simulation tool, and in Compass, the simulation tool developed by LESIA, as well as for on-sky data from LBT. For a variety of atmosphere and system parameters, they suggest a good qualitative performance along with reasonable computational effort.

Keywords: PSFR, PSF reconstruction

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