Subpixel pupil tracking on METIS for ELT

Hugo Coppejans*†[1], Thomas Bertram[1], Martin Kulas[1], Horst Steuer[1], and Carlos Correia[2]

[1]Max Planck Institute for Astronomy – Germany
[2]Space ODT Porto – Portugal

Abstract

The METIS instrument for ELT will use a pyramid wavefront sensor (WFS) for natural guide star based adaptive optics, instead of the more traditional Shack-Hartmann WFS. The pyramid produces four pupil images, one on each quadrant of the resulting WFS image. One of the dynamic problems that METIS will encounter is a lateral drift on these four exit pupils of the telescope instrument. This drift will occur over time and needs to be corrected for by shifting the Pupil Stabilization Mirror.

We aim to create a Pupil Position Control (PPC) algorithm specifically calibrated for the ELT. The lateral shift would need to be measured and corrected for on a subpixel level. The goal is to measure the lateral shift, on both axes, to within 1/10th of a pixel (with regards to the pupil images on the WFS).

The observed pupil image in METIS has unique characteristics that can both benefit and hamper attempts to calculate the center. Traditional methods such as center of gravity algorithms are too easily skewed by reflectivity differences or missing segments. Our approach is to build a series of sequential matched filters and correlate these to the pupil image to determine the level of lateral shift.

The PPC algorithm was evaluated for all stages of handover; open-loop prior to handover, closed-loop with 50 modes during handover and full closed-loop after handover. Through a series of simulations and unit tests we show that the PPC algorithm can achieve the desired accuracy, while still offering a level of invariance to rotation, warping, missing segments and luminosity differences in the pupil image.

Keywords: pupil positioning, wavefront sensor, center of gravity, matched filters, pupil stabilization mirror, lateral shift, SRTC, RTC

*Speaker
†Corresponding author: coppejans@mpia.de