The SCAO module of the E-ELT imaging camera MICADO


ABSTRACT

SAMI, the SCAO module for the E-ELT imaging camera MICADO, could be used in the first years of operation of MICADO on the telescope, until MAORY is fully operational. We present the results of the study made in the framework of the MICADO phase A to design and estimate the performance of this SCAO module.

1-SAMI top-level requirements

- WFS bandwidth: 0.85 ± 0.8 μm (visible WFS)
- Patrol: field of view: 85" 
- Repositioning accuracy: 2 mas for small (±0.3°) and large (few arcsec) dithers
- Relay optics transfer: 80% ± 0.8 μm
- Relay optics magnification: 1
- SAMI transmission: 80% in the NIR
- SAMI above MICADO in gravity invariant position
- SAMI thermal emission lower than 50% of the sky telescope thermal emission (goal 10%)

2-Pupil and field derotation

- WFS rotates with the H4 for a proper conjugation of the microfibers with the H4 actuators
  - Alternative: microfibers rotation with respect to H4 actuators + real-time control matrix update, but too risky for a 12 light instrument
- WFS + dichroic plate + MICADO fixed together and rotate with the field
  - rotate X/Y stages for offsets and pick-off
  - Pupil rotation stage: K-mirror
  - Alternative: retime the WFS assembly, but too complex given the rotation amplitude

3-Opto-mechanical design

- Optical design
  - Relay optics
    - Off-axis relay (476, 166, 166) on sky bench
  - Field derotator (for MICADO and WFS)
  - Dichroic plate
  - WFS
    - Off-axis Pupil, common mirror (306)
  - Correlation of WFS optical relay and pupil positions, set at infinity
- Transmission
  - Correlation of WFS mirror wavelength
  - Field stop
  - Mirror
  - Pupil imaging lens
  - H4 needed for ACS

4-Adaptive optics performance

- Median turbulence case atmospheric parameters from ESO document: seeing 0.65" at 0.5 μm and zenith, south angle 30°, Lp234 = 16.4 μm, Vm234 = 0.347 μm
- Error budget
  - τ50 x 50 μm x z
  - Temporal and residual errors
    - Single Shack-Hartmann sub-pupil and end-to-end simulations to estimate the noise errors
  - Simulation of an on-axis SCAO system on Zernike polynomials
    - From the (P) of a given Zernike mode, calculation of the transfer of the error budget from the whole WFS error budget, taking into account the error budget of the whole system
    - For each pupil, calculation of the transfer of the error budget of the whole system to the pupil, taking into account the error budget of each pupil
    - Calculation of the temporal and residual error of the whole order by weighting the temporal and residual error of each pupil and the residual error of the whole order by weighting the residual error of each pupil and the temporal error of the whole order
    - Calculation of the spatial residual error of the whole order by calculating the Fourier transform of the whole order error and the spatial residual error of each pupil
  - Fitting error
    - Turbulence term: στ(z) = 166 x seeing (μm) / 225
    - H1 coupling error: 50 nm rms assumed
    - Anisoplanatism error: 35% of the fitting error
  - Anisoplanatism error
    - Analytical computation from Chazot (1992)

5-Calibrations

- Optical design
  - Mechanical design
    - Maximum vertical deflection for a load of 30000 N (1.9° or 35000 N (6°) optical bench + optics) + 1000 N (calibration unit): 1.81 mm
    - 60% correction: 50 WFS (four times weaker than the usual steel elastic limit)
  - Cost and mass

6-Conclusions

- We have presented a possible implementation of a visible SCAO module for MICADO
- SAMI TLH fulfilled!