MICADO SCAO: first study of the impact on AO performance of the ELT/M4-M5 dynamics and of the tip-tilt command split between M4 and M5, using a data-based LQG controller

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Abstract

MICADO, the ELT first light near infrared imager, will enable to work close to the telescope diffraction limit. One of the challenges of the AO on ELT is to cope with windshake and vibrations affecting its huge structure. These disturbances have such an impact on tip and tilt modes that the standard integrator control fails to reach MICADO SCAO performance specifications. We present the design of a predictive controller taking into account:

- the temporal dynamics of the deformable mirror M4 and of the tip/tilt mirror M5
- the control split of tip/tilt commands between M4 and M5.

The proposed fully data-driven predictive tip-tilt controller is a linear quadratic gaussian (LQG) regulator built around a Kalman filter based on a stochastic disturbance model. This model is identified for tip-tilt modes (or for any number of low-order modes) from AO loop telemetry data. Higher optical modes are controlled using a standard integrator with optimized gain.

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Using end-to-end simulations performed with COMPASS for different disturbance scenarios, we studied the impact of M4 and M5 dynamics together with the tip-tilt command split on final performance, for both regulators: LQG controller and integrator.

The impact of M4 and M5 temporal dynamics can be simulated without increasing the simulation sampling period. We give performance in presence of these dynamics for both regulators

For the tip-tilt command split study, we chose to compare different split schemes in addition to the one designed by ESO. We showed that some split schemes proposed in the literature may lead to unwanted behaviors in closed-loop. As for the ESO M4/M5 split scheme, we show that combined with the data-driven LQG controller, it leads to the desired performance.

We then conclude that combining the M4/M5 dynamics and the ESO M4/M5 split, the LQG tip-tilt control enables to obtain the desired SCAO performance.

Keywords: SCAO, MICADO, mirror dynamics, tip&tilt command split