On how to gain 60nm RMS (for the instrument METIS) in AO Control, or: A stable DM fitting avoiding modal truncation

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Abstract

For the AO Control of the ELT instrument METIS a two-step method has been developed. First, we reconstruct the incoming wavefront from modulated Pyramid WFS measurements, second, we project this wavefront estimation on a set of modes defined on the M4 of the ELT. Here we focus on the second step, the stable fitting step of a wavefront on modes.
Previous methods have utilized modal truncation very bad seeing conditions or for faint guide stars. To stay stable, the number of modes was reduced, i.e., less spatial frequencies were used. If simply truncating modes one is not able to explicitly control spatial frequencies, the effects of the truncation are visible in the modal representation of the wavefront, the overall quality of the AO system decays.

To avoid these effects of truncation and to adapt the fitting step to the statistics of either full atmospherics screens or residual screens we introduce a regularized fitting step projecting on the M4 and subsequently on all available modes based on the same statistical information as the wavefront reconstructor.
We will present the properties of this fitting steps as well as improved closed loop simulation results for the instrument METIS where we gain 60nm RMS using the regularized projection instead of modal truncation. We will show that with very few control parameters, even with a constant set of parameters for the control, we obtain a stable and good performance of the AO system over all seeing and flux conditions studied.

Keywords: mirror projection, statistical regularization, optimal fitting

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