Cascade Adaptive Optics with two stages for XAO: how disentangled control can improve performance

Caroline Kulcsar*[1], Henri-François Raynaud[1], Nelly Cerpa-Urra[1,2], and Markus Kasper[2]

[1]Institut d'Optique Graduate School – Université Paris-Saclay, Institut d'Optique Graduate School, CNRS, Laboratoire Charles Fabry, 91127, Palaiseau, France – France
[2]European Southern Observatory – Germany

Abstract

Cascade Adaptive Optics (CAO) systems have been proposed to improve performance of XAO systems. A second correction stage takes as disturbance input the residuals of a first slower AO loop, namely the first stage. This allows for the use of more sensitive wavefront sensing in the 2nd stage, like a Pyramid wavefront sensor. Globally, a scheme with integrators in each loop improves performance significantly with respect to a single stage AO system. However, as the first stage signals are upsampled by the sencond stage, high-temporal frequency signals propagate and cannot be properly attenuated by the second stage integrator.
In order to overcome this effect, we propose to modify the CAO system by adding a control compensation in the second stage which disentangles the rejections of the two loops. This consists in sending the first stage commands at the second stage level so that the resulting rejection amounts to a stand-alone second stage, albeit with a control effort off-loaded to the first stage. In some sense, this transforms the whole CAO into a woofer-tweeter-like system, as presented at the OPTICA conference in July 2022. The disentangled CAO has also been equipped with a predictive controller at the second stage, namely an LQG regulator. We show the significant performance improvement gained by the disentangled CAO over the standard CAO scheme in terms of contrast, and how the LQG regulator improves it further at low angular separations. The effect on speckle life-time is also illustrated.

*Speaker