Using a pyramid wavefront sensor off-zero: from theory to practice

Arnaud Striffling*[1,2,3], Cedric Taissir Heritier[4,5], Romain Fetick[4,5], Jean-François Sauvage[4,5], Alexis Carlotti[6], Olivier Fauvarque[7], Benoit Neichel[8], and Thierry Fusco[9,10]

[1]DOTA, ONERA [Salon] – ONERA – F-13661 Salon cedex Air, France

[2]Institut de Planétologie et d'Astrophysique de Grenoble – Centre National d'Études Spatiales [Toulouse], observatoire des sciences de l'univers de Grenoble – 414, Rue de la Piscine BP 53 38041 Grenoble Cedex 9, France

[3]Laboratoire d'Astrophysique de Marseille – Aix Marseille Université, Institut National des Sciences de l'Univers, Centre National d'Études Spatiales [Toulouse], Centre National de la Recherche Scientifique – Pôle de l'Étoile Site de Château-Gombert 38, rue Frédéric Joliot-Curie 13388 Marseille cedex 13, France

[4]Aix Marseille Université, CNRS, CNES, LAM – Aix Marseille Univ, CNRS, LAM, Laboratoire d'Astrophysique de Marseille, Marseille, France – France

[5]DOTA, ONERA [Salon-de-Provence] – ONERA (DOTA) – France

[6]Institut de Planétologie et d'Astrophysique de Grenoble – Université Grenoble Alpes, IPAG Grenoble – France

[7]Institut Français de Recherche pour l'Exploitation de la MER – Institut Français de Recherche pour l'Exploitation de la MER - IFREMER, Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER) – France

[8]Aix Marseille Université, CNRS, CNES, LAM – Aix Marseille Univ, CNRS, LAM, Laboratoire d'Astrophysique de Marseille, Marseille, France – Laboratoire d'Astrophysique de Marseille Pôle de l'Étoile Site de Château-Gombert 38, rue Frédéric Joliot-Curie 13388 Marseille cedex 13 FRANCE, France

[9]Département d'Optique Théorique et Appliquée (DOTA) – ONERA – BP 52 29 avenue de la Division Leclerc 92320 Châtillon Cedex, France

[10]Aix Marseille Université, CNRS, LAM – CNRS : UMR7326 – France

Abstract

The pyramid wavefront sensor has become an essential asset for extreme adaptive optics systems, as it offers a high sensitivity. Its main drawback remains its nonlinear behavior. Using a gain sensing camera and a convolutional model enables the tracking of the first order nonlinearities, called the optical gains. They can be used in the reconstructor as an optimal modal gain integrator as they express the loss of sensitivity of the system in presence of residuals. Knowing them also makes it possible to offset the pyramid and maintain this offset during a closed loop. This operation allows to compensate for non-common path aberration, to maintain an absolute tip-tilt for fiber injection and to introduce dark-hole maps for high contrast imaging. This study explores the behavior of the offsetted pyramid wavefront sensor assisted by a gain sensing camera, in simulation and experimentally with the

*Speaker

AO-bench PAPYRUS. This bench, installed on the T152 telescope at OHP, has recently been upgraded to include an infrared imaging path. Preliminary tests to compensate for NCPAs by offsetting the pyramid during on-sky operation were carried out during the summer, using the optical gains estimation thanks to the gain sensing camera.

Keywords: Pyramid wavefront sensor, gain sensing camera, optical gains, NCPA, off, zero operation