New Adaptive Optics technique demonstrated

March 30 2007

On the evening of 25 March 2007, the Multi-Conjugate Adaptive Optics Demonstrator (MAD) achieved First Light at the Visitor Focus of Melipal, the third Unit Telescope of the Very Large Telescope (VLT). MAD allowed the scientists to obtain images corrected for the blurring effect of atmospheric turbulence over the full 2x2 arcminute field of view. This world premiere shows the promises of a crucial technology for Extremely Large Telescopes.

Telescopes on the ground suffer from the blurring effect induced by atmospheric turbulence. This turbulence causes the stars to twinkle in a way which delights the poets but frustrates the astronomers, since it blurs the fine details of the images.

However, with Adaptive Optics (AO) techniques, this major drawback can be overcome so that the telescope produces images that are as sharp as theoretically possible, i.e., approaching space conditions. Adaptive Optics systems work by means of a computer-controlled deformable mirror (DM) that counteracts the image distortion induced by atmospheric turbulence. It is based on real-time optical corrections computed from image data obtained by a 'wavefront sensor' (a special camera) at very high speed, many hundreds of times each second.

The concept is not new. Already in 1989, the first Adaptive Optics system ever built for Astronomy (aptly named "COME-ON") was installed on the 3.6-m telescope at the ESO La Silla Observatory, as the early fruit of a highly successful continuing collaboration between ESO

and French research institutes (ONERA and Observatoire de Paris). Ten years ago, ESO initiated an Adaptive Optics program to serve the needs for its frontline VLT project. Today, the Paranal Observatory is without any doubt one of the most advanced of its kind with respect to AO with no less than 7 systems currently installed (NACO, SINFONI, CRIRES and four AO systems for the interferometric mode of the VLT).

Present AO systems can only correct the effect of atmospheric turbulence in a relative small region of the sky - typically 15 arcseconds, the correction degrading very quickly when moving away from the central axis. Engineers have therefore developed new techniques to overcome this limitation, one of which is multi-conjugate adaptive optics (MCAO). At the end of 2003, ESO, together with partners in Italy and Portugal, started the development of a MCAO Demonstrator, named MAD.

"The aim of MAD is to prove the feasibility and performances of new adaptive optics techniques, such as MCAO, meant to work on large fields of view and to serve as a very powerful test tool in understanding some of the critical issues that will determine the development of future instruments, for both the VLT and the Extremely Large Telescopes," said Norbert Hubin, head of the AO group at ESO.

MAD is an advanced generation adaptive optics system, capable of compensating for the atmospheric turbulence disturbance on a large field of view (FoV) on the sky. It can successfully correct a 1-2 arcmin FoV, much larger than the ~15 arcsec typically provided by the existing adaptive optics facilities.

MAD was fully developed and extensively characterized by ESO using a dedicated turbulence generator (MAPS, Multi Atmospheric Phase screens and Stars) able to reproduce in the laboratory the temporal evolution and the vertical structure of the turbulence observed at the

Observatory.

MAD was then disassembled and shipped to Paranal for re-integration at the Nasmyth Visitor focus of UT3. The integration took about 1 month, after which the system was ready for daylight testing and further characterization.

"On the night of 25 March, we could successfully close the first MCAO loop on the open cluster NGC 3293," said Enrico Marchetti, the MAD Project Manager. "The system behaviour was very stable and the acquisition and closed loop operations were fast and smooth."

After routine checks on the closed loop stability and preliminary scans of the system parameters, the telescope was pointed to Omega Centauri, a very crowded area in the sky, and an optimal test case for extracting accurate measurements on AO correction performance with good spatial resolution on the FoV. Three 11 magnitude stars within a circle of ~1.5 arcmin diameter were selected as the baseline for wavefront sensing and the MCAO loop was closed successfully. Omega Centauri will be observed for several nights more, in order to test the AO correction in different seeing conditions.

"This is a tremendous achievement that opens new perspectives in the era of extremely large telescopes," said Catherine Cesarsky, ESO's Director General. "I am very proud of this ESO achievement and would like to congratulate all the involved staff for their prowess," she added.

The MAD images perfectly show the validity of the concept. The image quality was almost uniform over the whole field of view and beautifully corrected for some of the atmospheric turbulence.

Source: European Southern Observatory