AOLI First Light on the WHT (4.2m)

Summary: It is just a year since the STFC awarded a research grant to provide part of the support for developing AOLI. AOLI is an Instrument for near-diffraction limited imaging in the visible on ground-based telescopes. The technique has already been demonstrated on the WHT by our team with FastCam+NAOMI, and on the Palomar 5m, giving 35 mas resolution in I-band (>3 times Hubble) . Our goal is to provide this performance with close to all-sky coverage, using faint reference stars (I~17-18) and reaching science targets as faint as Hubble. AOLI achieves these faint reference star limits by using a novel low-order curvature wavefront sensor with photon-counting EMCCD detectors. We have just completed our first commissioning run on the WHT which was very successful in that virtually all aspects of the instrument performed as intended. However, exceptionally poor observing conditions (seeing often worse than 3-4 arcseconds with high humidity and little sky time) greatly limited the amount of data taken. Nevertheless valuable experience was gained and the prospects are excellent for using AOLI for science measurements in a later semester.

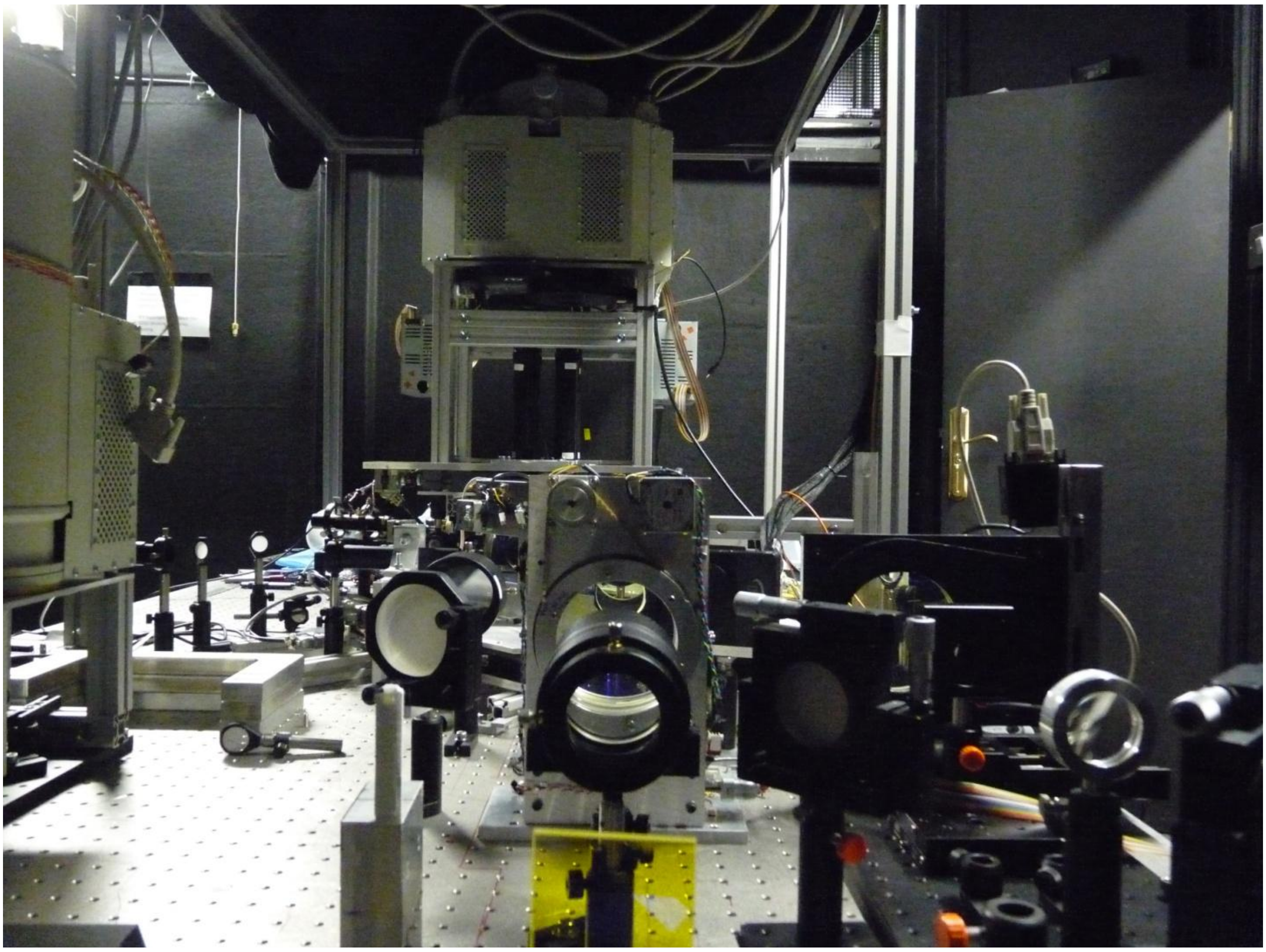

Figure: *AOLI mounted in the Naysmith GHRIL room on the WHT in September, 2013, as seen from the telescope. The light enters through a collimating lens followed by a prismatic atmospheric dispersion corrector. This is then reflected by the deformable mirror onto a pickoff mirror that intercepts the beam from the telescope, sending the light from the reference star (always on the optical axis of the telescope) to the wavefront sensor optics and detectors on the left-hand edge of this picture. The remainder of the field of view is passed to the science camera that sits at the back of the instrument. Because the EMCCDs cannot be butted we use a pyramid similar to that used in the original Hubble WF/PC architecture to reimage contiguous zones onto the 4 separate photon counting EMCCD science detectors. The calibration system may be seen on the right of this picture. It allows a high quality input feed to the instrument for precision set up before the start of the observing night.*

Detailed Report: Staff from the ING conducted a comprehensive review of the progress of the AOLI project in Cambridge in early July 2013. A detailed risk assessment was looked at particularly carefully. The conclusion was that it seemed highly likely that AOLI would indeed be ready to deploy on the WHT in

September 2013 as planned. The Director of the ING, Marc Balcells, allocated 2 nights at the end of September for a short commissioning run. The science part of AOLI was shipped out from Cambridge and the calibration subsystem was provided by the IAC. The instrument was assembled on the ground floor aluminising area and thoroughly checked there before moving into the Naysmith focus (GHRIL room) on the telescope. Detailed alignment tests were carried out that showed a clear problem with the Canary derotator, property of the Durham AO group which had a significant misalignment so that we were not able to use it. This caused some problems as we were forced to handle the variable parallactic angle but managed to update our atmospheric dispersion corrector software in time to take care of this. The calibration subsystem was intended to provide a high quality image input for AOLI so that we could set up the entire instrument before going on sky. This all worked very well indeed and we were able to demonstrate that the optical imaging quality of the entire system was very high, being limited almost entirely by the pixel sampling of the science detector even at the highest optical magnification of ~20 milliarcsecs per pixel. The calibration system also had a turbulence generated capability which allowed us to set up and align the curvature wavefront sensor. This is the key component that will enable us to use much fainter reference stars than is normally possible with adaptive optic systems. This also worked very well and so we were able to take a wide range of test data before going on sky. There were a number of minor glitches which we were able to work around but broadly speaking all the major components worked very satisfactorily and so we were excited to go on to sky for the nights of 24 and 25 September 2013.

Sadly, the observing conditions turned out to be extremely poor with high humidity forcing the closure of the WHT dome for most of the time. When it was dry enough to take data the seeing was found to be extremely poor indeed, much poorer than anything we have ever intended that AOLI will be able to work with the. Nevertheless, we did manage to take a small amount of data in those moments when the seeing became slightly less dreadful.

The only area that we were not able to demonstrate during this run was the fast fitting of the wavefront curvature using data from the wavefront sensor and closing that loop with the deformable mirror used to correct the wavefront. This was because the fitting and loop-closing software had not been developed so as to run fast enough (~100 Hz). This software is now being ported to a high-speed graphics processor unit which is already giving very fast fitting convergence. All the other changes that we need to make consequent on our experience at the telescope are relatively minor and principally straightforward engineering updates.

Our present plan is to carry out the necessary improvements and updates, shipping AOLI to the IAC in La Laguna (Tenerife) perhaps in March 2014 for final integration in the IAC laboratories. We would then be able to carry out a further short commissioning run ideally at the end of May or early June 2014 in bright time.

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