AAOMEGA IS COMMISSIONED

Rob Sharp and Will Saunders for the AAOmega team

AAOmega was commissioned in three runs in November, December and January. November marked first light for the new fibre feed, 39 m in total from the refurbished 2dF top end down into Coude West on the fourth floor. Simply routing the snake-like fibre-optic cable, encased in its armoured conduit, safely down the Coude mirror train, proved quite a feat for the indomitable day crew, who worked without (much) complaint in the full and terrible knowledge of the wrath of Kristin, John and the fibres team should anything happen to the fibres en route.

Once safely out of the telescope, the fibres entered Coude West and were removed from their protective transit torpedo to be mounted in the AAOmega slit exchanger, and system tests began in earnest. For the November run, the 2dF field plates were not fully populated, with only enough fibres and guide bundles for testing purposes being mounted. 2dF had at this time been through a major 10th birthday refit and upgrade, and there was much about the system that we needed to shake down. Additionally, a manufacturing defect in an LN2 dewar meant that only the blue arm was in operation for this first run. The run was a great success – integrating a system as complex as AAOmega with the telescope control and support astronomer is a major task and is one which requires AAOmega to be actually on the telescope and observing in order to complete. Test driving the control software, and confirming the astrometric accuracy of a number of 2dF top-end related upgrades progressed well and the blue camera achieved first light on a field of astrometric Tycho-2 stars. These observations may represent some of the least interesting spectra to be taken with the AAOmega system during what is hoped to be a long and illustrious career.

For the second commissioning run in December, both arms of the spectrograph were operational and the field plates fully populated with their 800 fibres (all 32 km-worth). While the first run focused on engineering and instrument control, the second run focused on multi-wavelength and multi-resolution observations of real science targets. High resolution radial velocity data was taken, to investigate what will be achievable in the future. Data was also taken for a number of fields from the 2SLAQ survey, to provide comparison data on faint LRGs and quasars.

As we go to press, the third and final commissioning run and the subsequent Science Verification observations have just been completed. Data has been taken for 12 programs in a wide variety of setups and data-taking modes. Nod&shuffle and cross-beam switching have been successfully commissioned, and some test mini-shuffled data (nod&shuffle using all fibres) looks very promising. Although many loose ends remain to be tidied up, AAOmega is now a working instrument.

Instrument performance and sensitivity

There were several areas where we were particularly concerned that the instrument live up to predictions. These were:

1) Would the fibres, with their input buttons and output slitlets, have the uniformity and quality required?

2) Would the light propagate through 39 m of fibre optics without significant focal ratio degradation?

3) Would the spectrograph optics perform as designed, giving the required imaging quality and uniformity (crucial for accurate sky subtraction and radial velocities)?

4) Would the overall throughput yield the expected gains of a factor of 2–3 with respect to 2dF?

The answers to all these questions look to be ‘yes’ (or at least ‘probably’). The uniformity of the data is superb, with fibre throughputs varying by about 10% both in absolute terms and spectrophotometric variations. The figure on the back cover illustrates this – it is 2 hours of co-added raw, low-resolution red data on faint targets – 350 simultaneous, long-slit-quality spectra.

The point spread function is remarkably Gaussian. It is extremely stable across the CCDs – varying in width by only a few percent for a given wavelength (as required for 1% sky subtraction). The blue camera gives images that meet or exceed specification (3–3.25 pixel FWHM). The red camera focus is less sharp (3.2–3.5 pixel FWHM, though still constant); there are known imperfections in the red camera alignment which will be rectified before routine science observations begin in late February.

The red arm throughput looks to be 75–80% of the predicted value. This is despite a telescope primary mirror that has not been cleaned for a year or aluminised for 2 years (re-aluminising will occur mid-February), and some pupil misalignment in the spectrograph. So we are confident that the red arm will live up to throughput expectations.

For the blue arm, the throughput is still unknown. The field lens in the camera remains frosted (from assembly in a hot and humid Sydney), and the moisture has proved stubborn to remove. A baffle accidentally both anodised and painted (hence trapping large amounts of moisture) is strongly suspected to be the cause of the problem. The amount of light lost to this frost – judging from its reflectivity and the scattered light on the detector – is clearly large, and we cannot estimate a reliable throughput at this stage. A strip-down of the blue camera is programmed before the first routine science observations in late February. The blue CCD is also less good cosmetically than the red one, with several bad columns near the middle of the detector which must be interpolated over.

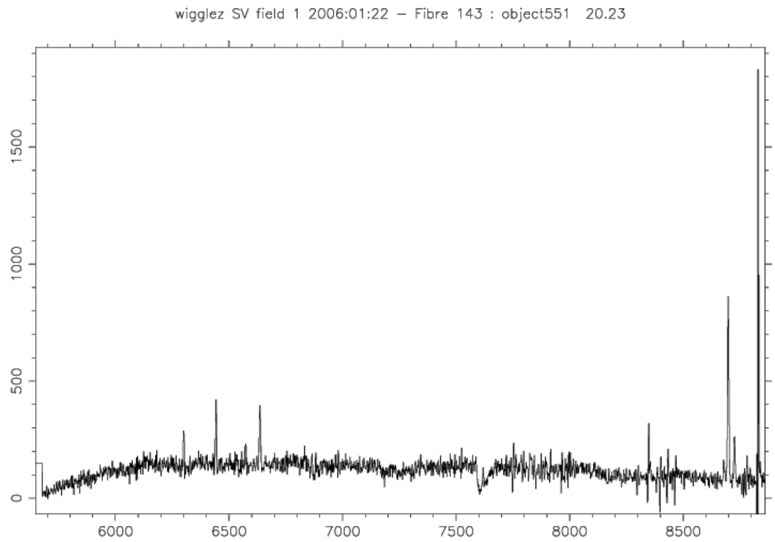

Figure 1: An r=20.23 galaxy spectrum at low resolution

Sky subtraction accuracy, using the traditional dedicated sky fibre technique will be crucial to many AAOmega projects, particularly at longer wavelengths. Preliminary extractions show sky subtraction often (but not always) better than a few percent and sometimes 1%. With improvements to the calibration system and data reduction software in the coming months, we hope to reach 1% consistently. This would mean that many programs will not have to resort to nod&shuffle techniques, which have significant efficiency overheads compared to dedicated sky-fibres.

Data reduction

An essential part of the success of 2dF was the availability of a fast, automated reduction package allowing observers to leave the telescope with fully reduced data under their belt. For AAOmega, we require reductions of equal robustness, but with a much higher level of precision to do justice to the data. As we go to press, work on upgrading 2dfdr to AAOmegadr is underway. Basic reductions are now straightforward, though some workarounds remain necessary at this stage. Further improvements and tuning will be implemented as we gather more experience with the instrument.

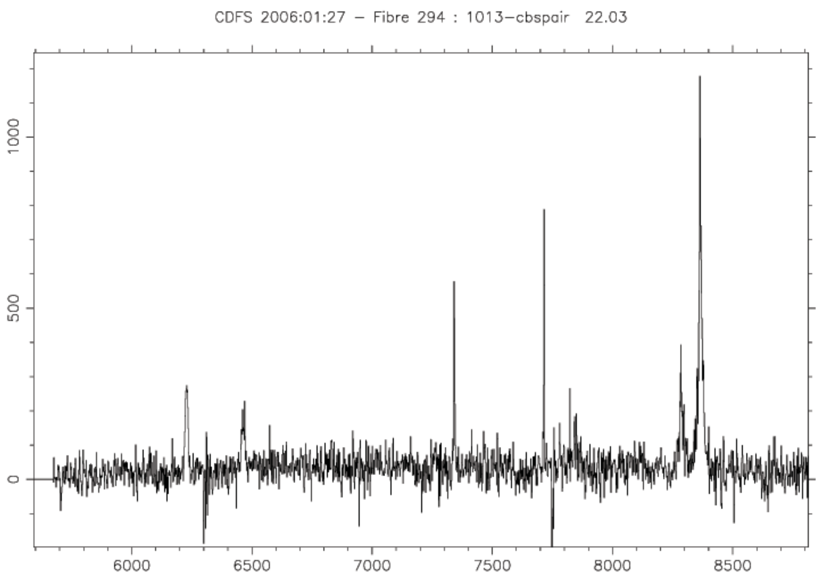

Figure 2: An r=22.03 galaxy observed with nod and shuffle in two hours

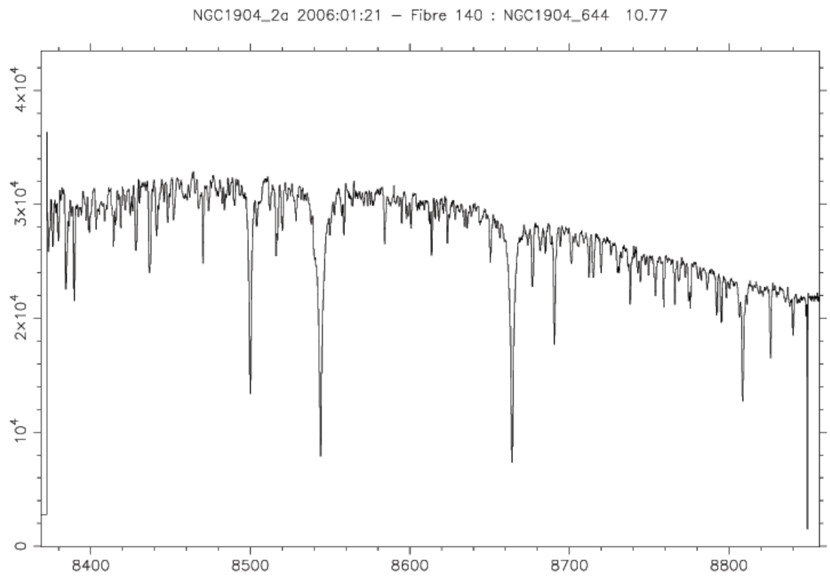

Figure 3: High resolution R=10 000 spectrum of a K=10.77 star in the calcium triplet region with S/N>100, revealing a wealth of absorption lines as well as the obvious calcium triplet features.

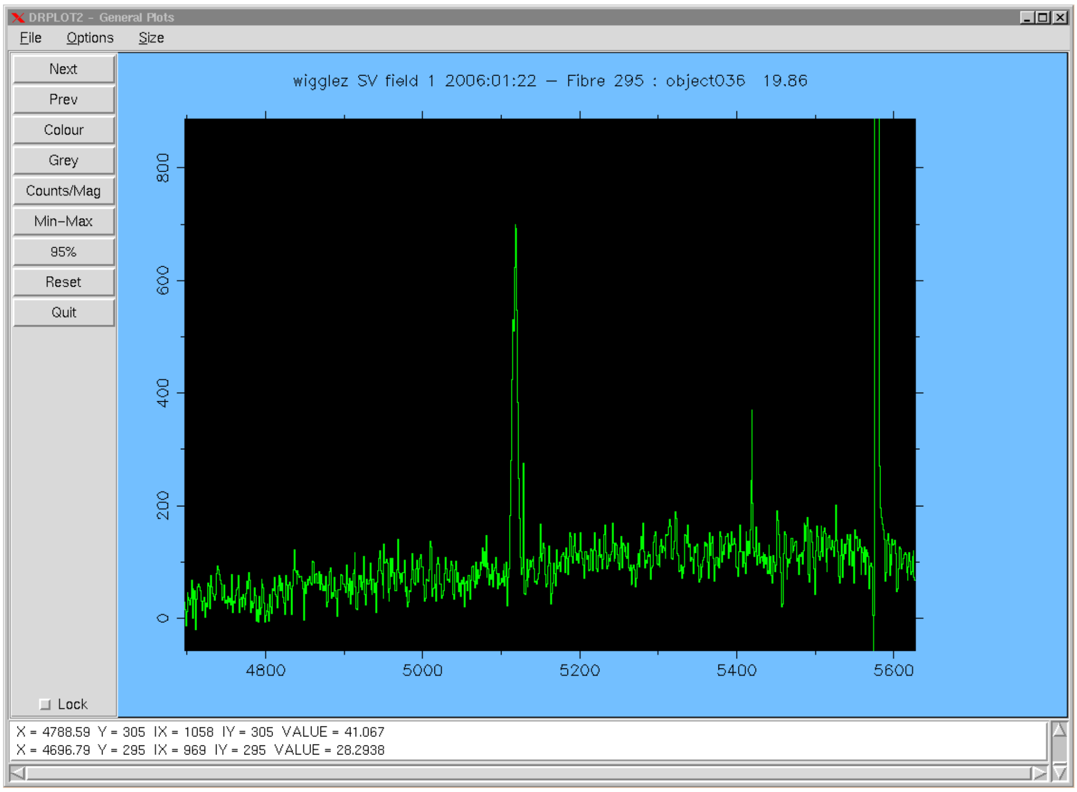

Figure 4: An r=19.86 galaxy with [OII] emission at z=0.37 as observed by the blue AAOmega camera with the 580V grating.

Sample data

Here we show some commissioning data showing what AAOmega is capable of in its various setups and modes.

Figure 1 shows an r=20.23 spectrum from the raw data shown above. The sky subtraction accuracy is about 2%; we are still working on improving this accuracy down to the target of 1%. Such an accuracy would render nod&shuffle unnecessary for most programs (it is 2–8 times less efficient than observations with dedicated sky fibres).

For the deepest data, nod&shuffle will still be needed, to achieve Poisson-limited sky subtraction. Figure 2 shows an r=22.03 nod&shuffle spectrum representing just 2 hours ON + 2 hours OFF data.

Figure 3 shows high resolution Calcium triplet data for a reddened K=10.77 star, with S/N>100 and resolution R=10,000, revealing a wealth of lines for abundance studies and promising sub-km/s radial velocity accuracy.

Figure 4 shows an r=19.86 galaxy with [OII] emission at z=0.37 as observed by the blue AAOmega camera with the 580V grating (2.5 hrs exposure). In this plot we have zoomed in on the interesting region of the spectrum (the actual spectrum extends from 370nm to 580nm) and show the plotting interface within 2dfdr.

SPIRAL IFU

As well as feeds from the two 2dF field plates, AAOmega will also support integral field observations with a refurbished SPIRAL IFU mounted at Cass. The SPIRAL system will be available with any AAOmega grating configuration, and will give 50% higher spectral resolution because of its smaller fibres. SPIRAL has a field of view of 22x11 arcsec. SPIRAL IFU mode is due for commissioning in June 2006.

This article is dedicated to Terry Bridges, for his dedicated work as project scientist in the design stages, and also for the wonderful and sadly missed bottle of whisky he left with us to celebrate first light.