EFOSC2 Episode IV: A New Hope

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As part of the long-term plan for the La Silla Observatory, ESO is reducing the number of instruments offered. EMMI and SUSI have been decommissioned at the NTT, and EFOSC2 has been moved to the NTT, replacing EMMI, to leave HARPS as the sole instrument at the 3.6-m. Here we describe EFOSC2 and its many capabilities, highlight the changes that the move to the NTT brings, and look forward to future plans for this instrument.

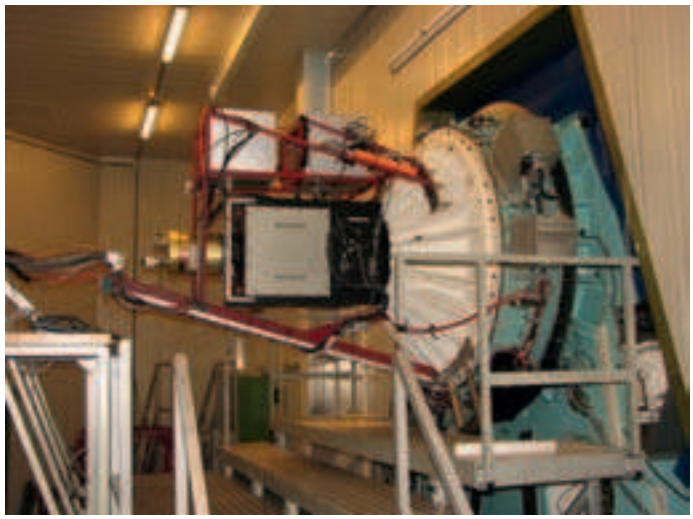

Figure 1. EFOSC2 mounted at the Nasmyth B focus of the NTT.

During the Transition Phase (2007–2009), the La Silla Observatory will see a reduction of the number of offered instruments and modes, with the goal of minimising the level of support from the Science Operations department. Within this framework, starting from Period 81, EFOSC2 is offered at the NTT instead of the 3.6-m telescope, initially together with SOFI. In April 2008 the instrument was transferred to its new home, the Nasmyth B focus of the NTT. Here we recall some of the long history of EFOSC2 and its many capabilities, and describe the changes that the move to its new telescope brings.

EFOSC2, the second ESO Faint Object Spectrograph and Camera, was originally built by ESO staff at La Silla for the NTT, to provide an imager and spectrograph for the first commissioning work and early scientific programmes before EMMI was ready. The design concept was based on the robust and versatile original EFOSC on the 3.6-m, but with various improvements including a larger CCD (see Buzzoni et al., 1984 and Eckert et al., 1989). It saw first light on the NTT on 11 May 1989, and the catalogue of Planetary Nebulae that came from commissioning observations for this telescope remains EFOSC2's most popular paper (Schwarz et al., 1992). Once EMMI arrived at the NTT in 1990, EFOSC2 was moved to the 2.2-m telescope, before moving in October 1997 to the 3.6-m, where it replaced the original EFOSC and served for over 10 years. Scientific highlights from the instrument during this time include work on dark matter in galaxy clusters (Böhringer et al., 2001) and also optical studies of supernovae associated with GRBs (Levan et al., 2005). Now, with the decommissioning of EMMI, EFOSC2 enters its fourth tour of duty, and returns to its original home at the NTT (Figure 1).

One of the main reasons for the longevity and reliability of EFOSC2 is the fact that its design is relatively simple, and yet it offers many observing modes and is highly versatile. It has undergone various improvements over the years, the most recent being the addition of a quarter wave plate for polarimetry (Saviane et al., 2007) and new high-resolution volume-phase holographic grisms (see following article by Saviane & Monaco).

Return to the NTT

With the move back to the NTT, some further changes were implemented, mostly due to the change of focal station from the f/8 Cassegrain focus of the 3.6-m to the f/11 Nasmyth focus of the NTT. The observing modes offered at the NTT are: Broad- and Narrowband Imaging; Coronographic Imaging; Polarimetric Imaging; Long-Slit Spectroscopy; Multi-Object Spectroscopy; Slitless Spectroscopy; and Spectropolarimetry. All of these modes were successfully tested during recommissioning on the NTT in April 2008.

The image quality of EFOSC2+NTT is very good: Figure 2 shows an image of the globular cluster NGC 3201, in which the stellar PSF is measured to have a FWHM of 0.6″. Figure 3 shows a re-commissioning image of the galaxy group Arp 321. At the NTT we measured the pixel scale to be 0.12″/pixel, the rotation centre to be near the centre of the CCD at pixel (1016, 990), and the orientation at zero rotator angle to be North up and East right. This information has been used to allow full World Coordinate System (WCS) information to be stored in the FITS headers of data taken with EFOSC2, which was shown in tests to be accurate to within the typical pointing accuracy of the NTT (a few arcseconds).

Figure 2. An image of NGC 3201 taken to demonstrate the image quality. The stellar Full Width at Half Maximum (FWHM) of the star images in the *R*-band was measured to be 0.6″, matching the DIMM seeing.

The field of view of the full 2 048 × 2 048 pixel CCD is 4.1′ × 4.1′, although there is some vignetting at the corners of the CCD, beyond a radius of approximately 2.4′ from the centre, which corresponds to approximately 8 % of the full field of view. There is also some distortion of the image PSF in the radial direction due to the focal reducing optics of the instrument, which was measured to reach 10 % beyond approximately 2′ from the centre. The lower pixel scale means that stellar PSFs are oversampled in all but the best seeing, so higher binning modes than the current standard 2 × 2 will be offered for imaging (3 × 3 and 4 × 4; also 1 × 3, 1 × 3, 2 × 3 and 2 × 4 modes for spectroscopy). These modes still remain to be implemented, but are expected to be offered during the first half of P81. The high sensitivity in the blue is maintained following a UV-flooding of the CCD during the move, while the response is better at red wavelengths than it was at the 3.6-m. The zero-points for *UBVRI* are shown in Figure 4. The fluxes for a 15th magnitude star in e-/sec are $U = 5.7 \times 10^3$, $B = 2.9 \times 10^4$, $V = 3.3 \times 10^4$, $R = 3.5 \times 10^4$, $I = 1.5 \times 10^4$.

In the spectroscopic modes the change of plate scale means that the old slits have different effective widths, so new slits with 0.3″, 0.5″, 0.7″, 1.0″, 1.2″, 1.5″, 2″, 5″ and 10″ widths have been prepared, each with a length of 4.1′ (i.e. covering the full field of view). The default slit alignment is in the East-West direction (horizontally across the chip), so to align the slit along a given Position Angle, an offset of PA + 90° must be applied to the rotator (this is done automatically when presetting to the parallactic angle). During commissioning it was found that, with the instrument now mounted horizontally at the NTT Nasmyth B focus (instead of vertically at the 3.6-m Cassegrain), there is significant flexure. A shift of 3.5 pixels in the spectral (y-axis) direction was measured over the full rotator motion. Further work is planned to stiffen the instrument, but those users wanting to measure radial velocities are advised to take regular arc lamp exposures.

The polarimetry modes of EFOSC2 are the most strongly affected by the move, as the reflection from the NTT M3 introduces linear polarisation dependent on the telescope pointing. Measurements of both polarised and unpolarised stars at many telescope positions were taken during the commissioning time, and the instrument polarisation as a function of telescope position is now being modelled.

Figure 3. The interacting galaxy group Arp 321, taken as a test image during the recommissioning.

The future of EFOSC2

The demand for all of EFOSC2's observing modes remains high. With 51 proposals submitted for P82, it is the most highly requested La Silla instrument, while in terms of time requested (8 % of total time requested on all ESO instruments) it is in higher demand than all VLT instruments except FORS2 and VIMOS, even with the end of service mode observing at La Silla. With the end of EMMI operations, EFOSC2 now takes on the considerable load of being ESO's only general-purpose imager and spectrograph on a mid-size telescope. With this in mind we are also planning further future improvements to the instrument: We are in the process of looking for a good replacement CCD that would give improved readout noise and readout speed, and would be compatible with a continuous flow cryostat to simplify operations and providing improved long-term stability. Implementation of calibration OB's (CALOB) and a full reduction pipeline will also enhance operations in the near future. We look forward to many more years of exciting science with EFOSC2 in its new home.

Acknowledgements

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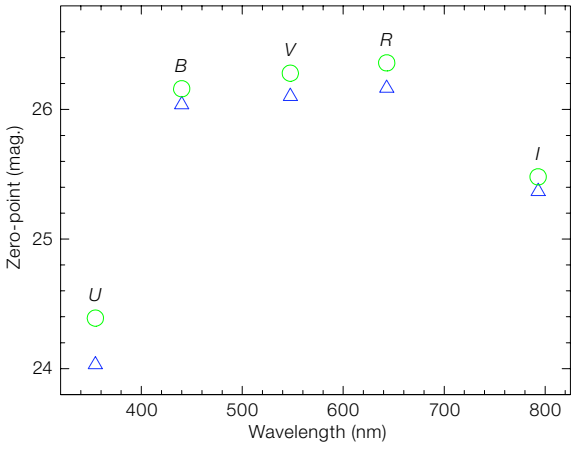

Figure 4. The *UBVRI* zero points of EFOSC2 (with CCD No. 40) on the NTT. The new values (green open circles) compare favourably with the mean values (blue open triangles) for the same instrument on the 3.6-m.