4. AAO facilities

This chapter summarises existing instrumentation and research facilities at the AAO, and provides details on new instruments, computer developments and enhancements to existing instruments. It also outlines services provided by the AAO to the user communities, such as service observing.

The AAT and UKST are the heart of the AAO. To maintain its position as a leading-edge research organisation, it is essential for the AAO to equip these telescopes with state-of-the-art instrumentation and to provide a range of facilities for visiting astronomers.

The instrumentation for the telescopes involves much more than the new instruments themselves; they must be fitted with the most sensitive electronic detectors for visible light and infrared radiation, have sophisticated computer systems for both control and data-taking, and powerful software for on- and off-line data analysis. The AAO aims to provide astronomers with a complete system for the acquisition and analysis of astronomical data.

The Two-degree Field (2dF) facility for the AAT is now fully operational and in regular use, and this year was offered for research for both semesters. The development of a similar instrument for the UKST—the Six-degree Field facility (6dF)—was approved during the year.

Full descriptions of progress on 2dF, as well as other AAT and UKST instrumentation projects, are given below.

AAT facilities

Instruments available at the AAT in mid-1998 are summarised in Table 4.1. Further information is available in the AAO Observer's Guide, in the relevant instrument user manuals, in the AAO newsletters and on the AAO www pages.

Table 4.1 Instruments available on the AAT at 30 June 1998

Focus Equipment	Mode	Detector
Prime		
Two Degree Field (2dF) 400 fibre multi-object spectrograph facility	f/3.3	Two dedicated Tektronix 1K CCDs
Prime focus camera—aspheric plate, doublet and triplet correctors, sub-beam prism	direct f/3.3	Tek thinned CCD Range of types of sensitised photographic plates 254 × 254 mm
Focal reducer	f/1	Thomson CCD
Cassegrain		
Imaging		
Auxiliary camera	f/8 or f/15	Thomson or Tek CCD
Infrared equipment		
IRIS 128 × 128 format infrared camera and low-resolution spectrometer, with imaging, spectroscopic and polarimetry modes	f/15 or f/36	Rockwell HgCdTe array
3D Integral Field Spectrograph made available under agreement with MPIE	f/15	Rockwell HgCdTe array
Spectrographs		
RGO spectrograph, 25 and 82 cm cameras, FOCAP multi-object fibre optic coupler, spectro-polarimetry modes	f/8	Tektronix 1 K CCD, MIT/LL 2K × 4K CCD and other CCDs
Faint object red spectrograph (FORS), sharing slit of RGO spectrograph and optional dichroic beam splitter	f/8	GEC CCD
Wide-field imaging Fabry-Perot interferometer (Taurus II) with tunable filter (TTF) and charge shuffling. Wollaston prism polarising module	f/8 or f/15	Tektronix 1K CCD and MIT/LL 2K × 4K CCD
Low dispersion survey spectrograph (LDSS II)	f/8	Tektronix 1K CCD and MIT/LL 2K × 4K CCD
Facilities for visitors' own equipment		
Coudé		
UCL echelle spectrograph, 70 cm camera (UCLES)	f/36	Tektronix 1K CCD and MIT/LL 2K × 4K CCD
Ultra-high resolution facility (UHRF)	f/36	Tektronix 1K CCD and MIT/LL 2K × 4K CCD
Facilities for visitors' own equipment		

Most instruments on the AAT are used by scientists as common-user facilities, which means that observers make their own observations with backup support from Observatory staff. However, some highly specialised but infrequently used instruments are no longer fully supported by the AAO and therefore generally require an experienced user as one of the collaborators. This group of instruments includes FOCAP, LDSS and Taurus II. Instruments owned by other institutions are sometimes used on the telescope and may be available for collaborative projects.

UKST facilities

The UKST operates in two modes; photography, for surveys and service observing, and as a common-user instrument with the FLAIR fibre spectroscopy system.

There are two basic photographic options at the UKST:

direct imaging of the sky in different wavebands from ultraviolet to infrared, selected by the appropriate choice of photographic emulsion and filter;

slitless low dispersion spectroscopy through thin, full-aperture objective prisms.

Photography has traditionally been carried out on glass plates. However, because of superior performance, Kodak Tech Pan film is now used for most non-survey observations. Film is available in only one spectral sensitisation, but is panchromatic and is used for U-, V-, R- or hydrogen-alpha band exposures.

The second mode of operation on the UKST is higher dispersion multi-object spectroscopy with the fibre-optic FLAIR system, which uses optical fibres to feed the light from 90 individual selected targets to a bench spectrograph and CCD camera.

The 2dF

The 2dF project gives the AAT an unsurpassed two-degree field-of-view at its prime focus which is equipped with 400 optical fibres for multi-object spectroscopy. The system is at the forefront of multi-object spectroscopy for large telescopes and represents one of the most complex astronomical instruments ever to be installed on a ground-based facility.

This year the 2dF was regularly scheduled for both semesters, and several scientific projects made significant advances. During the June 2dF run scientists configured 8 fields during the course of one cloudy night. This effectively meant the observation of 3200 objects on one night.

Although the June nights are obviously longer, this has doubled the

number of fields able to observed in one night. This has been brought about by the reduction in configuration time for each field from approximately 2 hours to 1 hour 20 minutes (8.5 seconds per fibre).

Taurus tunable filter

The TAURUS Tunable Filter (TTF) is producing impressive data for a diverse range of astrophysical studies. This instrument is set to revolutionize the way in which intermediate to narrowband imaging is carried out. Now that the blue TTF has been successfully commissioned, the instrument allows for wide-field (4.5 – 9 arcminutes) narrowband imaging over 370 – 1000 nanometres, where the bandpass can be set anywhere in the range 0.5 – 8 nanometres full-width half-maximum.

The associated development of CCD charge shuffling has been highly successful and has played a crucial role in about half the TTF projects to date. During the year, TAURUS II secured 17.5 per cent of the total number of nights.

The reflectance phase (which arises when the plate spacing is comparable to the coating thickness) can now be calibrated rapidly with a Hartmann test based on charge shuffling, and therefore resolving powers of order 100 can now be reached with the TTF.

IRIS 2

IRIS 2 is the current major ongoing instrumentation project at the AAO. Work commenced last year, and on-telescope commissioning is expected to start early in 2000.

IRIS 2 is designed to replace all the functions of the original IRIS, which is shortly to be decommissioned. The design is based around a 1024 × 1024 Rockwell HgCdTe Hawaii array, though provision has been made to upgrade this in future to a 2048 × 2048 device, if funds are available. The array used, limits the instrument to wavelengths below 2.5 microns.

In particular, IRIS 2 will provide a wide field imaging capability (7.7 arcmin × 7.7 arcmin) with 0.45 arcsec/pixel (providing Nyquist sampling of the typical seeing). It will aso provide JHK spectroscopy with a resolution of at least 1000, and, if technology allows, 3000. IRIS 2 will also provide an integral polarimetry capability.

Currently, the major design work is being completed, manufacture is expected to begin before the end of 1998.

6dF

The development of the Six-degree Field facility (6dF) for the USKT was approved during the year. 6dF is a multifibre spectroscopy system similar but smaller and less complex than the 2dF. Three interchangeable fibre plateholders will be constructed, each having 150 self-retracting fibres arranged in a circle around the 6-degree field.

Fibre positioning will take place on the curved focal surface and a fully robotic positioner will be used. The positioner will make extensive use of air-bearings, and the fibre gripper will be pneumatically controlled and driven. The target set-up time for the 150 fibres is one hour.

The 6dF will allow the UKST to undertake the first truly whole-hemisphere spectroscopic survey, ensuring that the UKST remains very productive into the next century.

Hydrogen-alpha filter

The high-specification, hydrogen-alpha interference filter came into regular use on the UKST during the year. At 356 × 356 mm (14 × 14 inches), this is one of the largest optical interference filters ever made for astronomy.

Excellent progress was made with the hydrogen-alpha survey of the southern Milky Way and the Magellanic Clouds. This survey, which began in 1997, will be vastly superior to any other optical survey of ionised gas in the galaxy, in terms of the wealth of data anticipated. As reported in Chapter 3, one significant advance has been the discovery of 300 previously unknown planetary nebulae.

External Projects

The AAO's expertise in fibre optics technology for astronomy was recognised in May 1998 when it was awarded the contract (together with Mount Stromlo Observatory and the University of NSW) to build a fibre positioner for the European Southern Observatory's Very Large Telescope (VLT) in Chile. The positioner, known as OzPoz, is due for completion by 2003. Some project staff have been employed and initial design work has commenced. A preliminary design review will take place in March 1999.

As well, the AAO is involved in smaller design studies for optical fibre-based projects. These include other work for the VLT and an optical/near-infrared fibre facility for the National Observatory of Japan's Subaru telescope atop Mauna Kea, Hawaii.

The AAO is committed to making sure that these external projects will not compromise our current level of service provided to Australian and British astronomers.

Enhancements to existing instruments

CCDs

In October 1997, the AAO began to commission its first large format CCD, an engineering grade device from the AAO's membership of the Massachusetts Institute of Technology, Lincoln Laboratories (MIT/LL) CCD Consortium. This device MIT/LL2 has 15 micrometre sized

pixels in a 2048 × 4096 format. It is a thinned detector, but has an anti-reflection coating optimised in the infrared, producing superior performance in the red, but relatively poor performance in the blue. It has excellent read noise performance, acceptable cosmetics, and less fringing in the red than the AAO's workhorse Tek detector. This device was made available to observers from Semester 1998A onwards, and has proved extremely popular with all observers working longwards of about 500 nanometres. In particular, TTF observers have used almost nothing else since its introduction.

The AAO also plans to commission its first science grade device from this consortium run (MIT/LL3). This device has an unusual 'deep depletion' construction, which should optimise its performance in the red, and further reduce fringing. It will be commissioned in the forthcoming LDSS^{++} run in October 1998, and is expected to be well matched to the LDSS^{++} red optimised performance goals.

Prime focus upgrade

The AAO is upgrading the prime focus imaging facility of the AAT. This will involve the construction of a new CCD camera head to replace the existing camera head (which will be retained for photographic purposes). The new camera head will be remotely controlled, eliminating the need for an observer to ride in the prime focus cage. It is expected that the new facility will be commissioned in mid-1999.

Wide Field Imager (WFI)

The AAO and MSSSO are constructing an 8192 × 8192 pixel CCD mosaic for imaging use at the prime focus of the AAT and the Cassegrain focus of the MSSSO 1-m telescope. This instrument was described in detail in the 1996/97 Annual Report. WFI is expected to be commissioned in the second half of 1999.

LDSS^{++}

The AAO is planning to upgrade the LDSS. The upgrade, LDSS^{++}, will yield an increase in performance by up to a factor of three in the throughput of LDSS. This will be achieved by the use of the new high-resistivity MIT/LL CCD, volume phase holographic gratings and a telescope-nod/CCD charge shuffling mode. The latter development will permit the use of small apertures rather than slits, resulting in a factor of ten gain in multiplex advantage (from thirty to three hundred objects) for this survey instrument. It is planned to commission LDSS^{++} in October 1998 with spectroscopic observations of faint galaxies in the Hubble Deep Field-South.

Iodine cell for UCLES

During the year, the Lick Observatory backup iodine absorption cell was installed for use with the UCLES spectrograph. The iodine cell is used to provide a fiducial wavelength scale for making precise Doppler velocity measurements. Velocity precision of 5 metres per second has been attained with this instrument, although this level of precision requires active modelling of the observed spectrum and of the instrumental point-spread-function. The iodine cell is being used in the extra-solar planet survey.

FLAIR Interim Upgrade

Several important developments have occurred which have significantly improved the way that FLAIR operates.

The most important of these is the commissioning of an interim magnetic-button type fibre-positioning system. Currently one plateholder has been converted to magnetic buttons and was successfully commissioned on the telescope during May 1998. It has since been used to monitor the Gamma ray burst event (GRB980425). Once some minor additional modifications are performed, and barring any unforeseen problems, a second plateholder will be converted in the second half of 1998.

Both plateholders should be available in their new magnetic button format by Semester 1999A. Coupled with the changes to the fibering process, several significant improvements to the spectrograph have been implemented. As well, there is now remote control of spectrograph focus, Hartmann shutter, grating rotation, RA dec. fine motion and FLAIR plateholder rotation. All these operations can now be performed from the FLAIR console control area in the UKST common room.

MAPPIT

MAPPIT is an interferometer installed at the coudé focus of the AAT and dedicated to high resolution imaging. It uses the principle of Non-Redundant Masking, and is able to reach the diffraction limit of the telescope (0.03 arcsec) for observations of bright stars.

A new system, MAPPIT2, is being developed which will combine the existing interferometer with a Shack-Hartmann wavefront sensor, providing information on the instantaneous wavefront distortions. This will permit more detailed analysis of the data, allowing observations of fainter and more complex objects.

The new wavefront sensor was successfully commissioned in June, together with a 10 ms read-out time for a 523×1 window on the Tek CCD. The system, with the wavefront sensor and the interferometer working together, is due for commissioning in early 1999.

Consolidation project

As part of a program to upgrade observer facilities, the observing area at the AAT has been remodelled. The decommissioning of a number of instruments last year enabled the extension of the area to provide a more efficient and comfortable working environment. At the same time, a suite of software tools, to aid in the analysis of astronomical data, has been provided.

Other facilities

Computing facilities

The Observatory has a program of information technology enhancements and upgrades to keep both telescopes operating as front-line facilities. State-of-the art computing facilities for instrument control, data acquisition and data reduction, at both Siding Spring and Epping, are vital components of the infrastructure of the Observatory.

Four of the main Unix systems used for data processing and instrument control were upgraded at the AAT and Epping. Memory and disk space resources on these systems were significantly improved. New, high-capacity tape devices were installed at each site for backing-up disk systems.

A program to upgrade the computer data-cabling infrastructure at both sites began. The Epping laboratory has been recabled with Category 5 network cable and, at the AAT, a start has been made on installing fibre optic and Category 5 cable throughout the telescope building.

Software

The software group maintains the general computing facilities of the observatory, and develops the specialised software needed by new instruments such as 2dF and IRIS 2.

For the first time in some years, the year's software workload was not completely dominated by 2dF. Although 2dF still requires work to bring it to final completion, this now comprises only maintenance work and occasional enhancement. This has allowed work to begin on IRIS 2 and the new CCD controllers. The IRIS 2 design process is now well underway, heading towards a critical design review in October 1998.

The software group continues to maintain the DRAMA software that underpins the 2dF system. It also provides occasional support for other observatories such as those on La Palma and Hawaii that are using

DRAMA itself, and for Gemini, which is using some of the DRAMA sub-systems. DRAMA has recently been ported to Linux and to Windows NT, providing two different options for using it in systems built around PC hardware.

The SUN workstations that form the backbone of the AAO computing systems have now moved almost completely from the older SunOS operating system to the newer Solaris system. This should allow the systems staff to concentrate on providing the best available facilities on the one system rather than having their effort diluted by the need to support multiple systems.

Support facilities

The AAO maintains comprehensive facilities to enable visitors and staff to prepare for observations and to analyse their data. There is a plate library in the Schmidt building and chart rooms in the AAT dome and at Epping, all with facilities for the inspection, measurement and photography of sky survey and other material. A quarterly newsletter is also produced and distributed. The AAO also offers astronomers access to digitised sky survey data either in the form of CD-ROMs or from the COSMOS and APM databases available on the www.

Library

One of the largest astronomical collections in Australia is held at the AAO library and, together with the libraries of MSSSO and Radiophysics Laboratory/ATNF at CSIRO, provides an essential facility for the astronomical community. Electronic databases and online search facilities are kept up-to-date, and ensure that the library is part of an international network of specialist astronomical libraries. New shelving was installed this year in the Observatory publications area of the library, providing more space for the journals collection and room for its expansion for some years to come.

Data archive

The AAO maintains a complete archive of data obtained with the telescopes. Most of these data are in digital electronic form on magnetic tapes. A system to archive the raw AAT data on CD-ROMs is now in place, and older data will be transferred to the new medium over the next few years. Data are available upon request after an initial proprietary period, usually two years.

An index to the data archive is now available on the world wide web but the full archive is not yet complete. All observations using standard AAT instrumentation taken since mid-1994 have been indexed. As well, indexes to most of the data taken with the IPCS detector since 1976, and all photographic plates taken at the AAT since 1974 are available on line.

Other AAO programs

Service observing

The service observing program at the AAT was relaunched in July 1997. Applications forms and full information on the service system are now available on the world wide web and all service proposals are submitted electronically.

The service program was extended to include programs that require up to three hours of observations. Service time is normally used for programs that require a small amount of data to complete a project, to look at individual targets of interest, or to try out new observing techniques. All service proposals are refereed by a three-member panel and are graded on a basis of scientific merit. During the year an exceptionally large number of 80 service proposals were received. Of these, approximately one-half were for the RGO spectrograph. Service observations were taken with the RGO and also with the CCD prime focus imaging, Taurus II/TTF, RGO, UCLES and UHRF facilities.

Students

The AAO continued to encourage students to use its facilities at both sites, and to work at the AAO for extended periods. There is also a policy of employing undergraduate students of astronomy as assistant during vacations. In total, six student from the UK and Australia were employed during the year. AAO staff were responsible for the joint supervision of the PhD research students. These were Robert Smith (IoA),Michael Brown (Melbourne), Heath Jones (MSSSO), Kathryn Deeley (NSW) and Andrew Walker (Wollongong).