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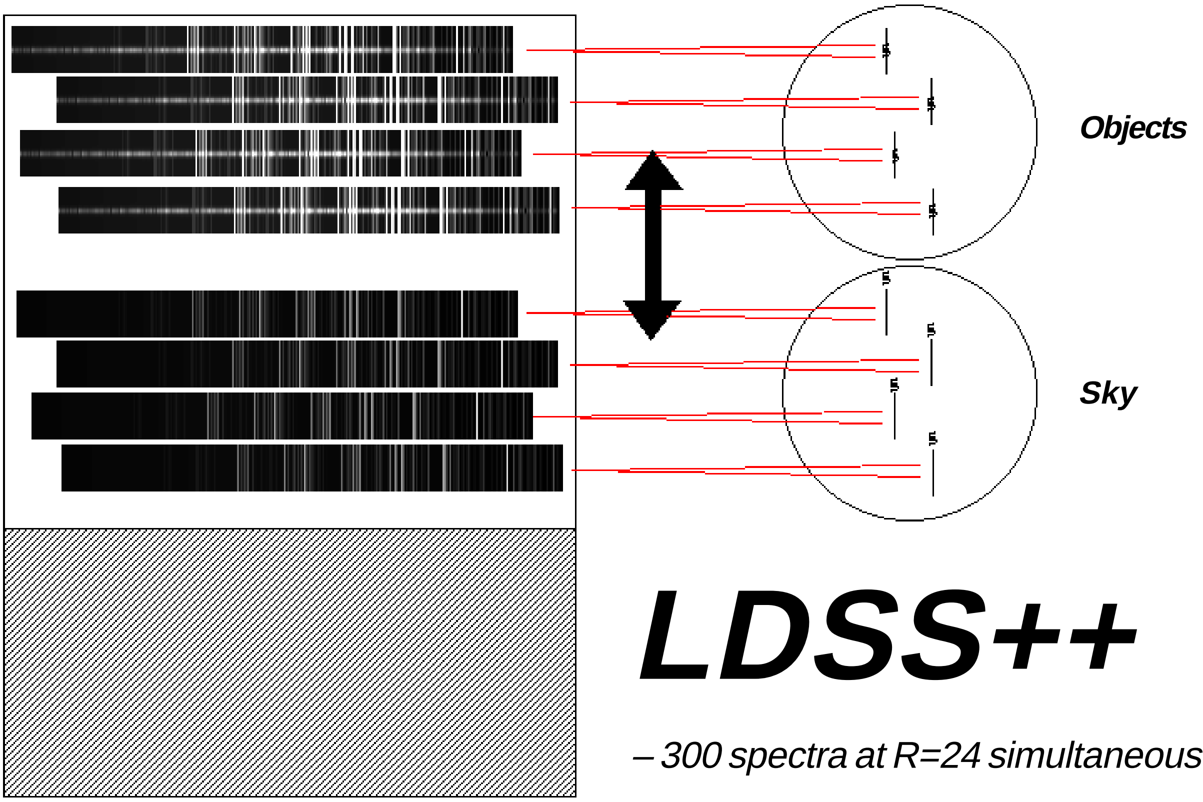
AAO NEWSLETTER

ANGLO-AUSTRALIAN OBSERVATORY



LDSS++

– 300 spectra at R=24 simultaneously...?

Plans are underway to greatly improve the performance of the Low Dispersion Survey Spectrograph. See page 9 for details.

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DIRECTOR'S MESSAGE

Brian Boyle

There have been a number of significant scientific and technical developments at the AAO since the last newsletter. Possibly the most welcome news is that the major 2dF galaxy and QSO redshift surveys are now making rapid progress. Over 5000 galaxy and 600 QSO redshifts have been obtained. The QSO sample already represents the largest single homogeneous QSO catalogue at these depths ($B<21$). At the current rate of 1500 spectra per night, the 2dF galaxy survey will also soon outstrip the Las Campanas survey. The fact that surveys of this size can be obtained in just a few nights' observations amply demonstrates the power of 2dF. Karl Glazebrook and Ian Lewis give a full status report on 2dF in this newsletter.

As 2dF begins to demand less of the AAO's resources, other instrumentation programmes can gain a higher profile. The largest of those is IRIS-2, the new infrared camera/spectrograph for the AAT. The optical design for IRIS-2 is now essentially complete, and work is now in progress on the detailed mechanical design. Probably the most significant developments have, however, occurred in two other instrumentation projects: the successful commissioning of the MIT/Lincoln Laboratories CCD, and the emergence of the LDSS++ project.

After many years where the AAO lagged behind other world observatories in availability of the large-format CCD arrays, the AAO now finds itself in the enviable position of being the first observatory in the world to offer the new 2K x 4K MIT/LL CCD to observers. Full details on the commissioning of this chip may be found in Chris Tinney's article.

Details of the LDSS++ project can be found in the article by Karl Glazebrook (also on the front cover). LDSS++ is an innovative upgrade to the existing LDSS spectrograph. Initially motivated by the scientific opportunity to carry out a deep spectroscopic survey on the HDF-S, this relatively modest upgrade (in resource terms) could lead to major gains in throughput and multiplex advantage on LDSS. This will open up a new area of astronomical parameter space at faint magnitudes for AAT users to exploit.

Perhaps the most pleasing aspect of both the MIT/LL commissioning and LDSS++ project is that, despite the demands placed on the AAO by large projects such as 2dF and IRIS-2, the AAO still has sufficient flexibility to respond rapidly to scientific or technical opportunities as and when they arise.

There has also been a significant organisational change over the past 3 months. Llew Denning has now been appointed officer-in-charge of the Siding Spring site, and Fred Watson as the astronomer-in-charge. This redefines the division between these jobs on a functional basis, rather than on a telescope basis. This move is part of our strategy to achieve greater integration between the telescopes, and our commitment to increasing the staff astronomer profile at the AAT.

Finally, as the newsletter completes its first year in its new format, I would like to thank everyone who has supplied feedback on the newsletter. The feedback has been very positive. The newsletter is an important part of our output, and I believe the range of scientific and technical articles submitted to the newsletter over the past year attests well to the ongoing scientific productivity and technical innovation of the AAO.

TAPE MEDIA – A WARNING

Ray Stathakis

Recently, a hardware fault discovered in a DAT drive at the telescope has highlighted a problem with tape media. This drive produced tapes that could be read successfully with the same drive, but not with any other drive. The problem did not affect all tapes, but could affect anyone who has written a DAT tape in the terminal room of the AAT (on aatsse) prior to last December. This drive has now been replaced, but we have on occasion had similar reports with exabyte tapes.

If you have a DAT tape written at the AAT prior to December 1997 which you have not yet read, please check it. Our system manager has the faulty drive and can produce a readable copy of any problem tapes. Contact Bob Dean (rgd@aaocbn.aao.gov.au). Raw observations are available from our telescope archive. Send requests to the general account archive@aaocbn.aao.gov.au and for more information see our web page at http://www.aao.gov.au/local/www/ras/archive/archive.html.

In general, reading the tape back on the same drive is not a good test that the tape will be readable back at your home institution. If possible, check your tape on another drive. If no other drive is available, please check that you can read the tape as soon as possible after your return to your home institution. This will ensure minimal delay in accessing your data.

DISSECTING THE RHO OPHIUCHI CLOUD

Ted Snow (Colorado)

ρ Ophiuchus is a hot star which belongs to an open star cluster which is embedded within an extended interstellar cloud of diffuse gas and dust. The ρ Oph region is located on the edge of a dark molecular cloud and is well known from the strong reflection nebulosity that is caused by the scattering of starlight from dust grains in the interstellar cloud.

We are studying the three-dimensional structure of the ρ Oph interstellar cloud using a combination of data taken with the Hipparcos satellite and the Ultra High Resolution Facility (UHRF) on the AAT. Hipparcos data were taken for the brighter stars in the cluster, through the Guest Investigator program, to determine the stellar parallaxes. At the distance of the ρ Oph cloud, of 125 pc, the absolute values of the stellar parallaxes have large uncertainties. However the relative sequence of distances to the stars is more certain and it is possible to distinguish between the nearer stars in the cluster from the more distant stars.

The UHRF spectra were taken for the same set of stars that were observed with Hipparcos. The UHRF has a uniquely high spectral resolution and so allows for fine spectral details to be studied. The UHRF spectra were taken at a wavelength selected to show absorption by sodium atoms in the gas clouds which lie in front of the stars. Light from a star passing through an interstellar cloud is partially absorbed by the gas in the cloud. The extent of the absorption increases with the amount of material that the light has to pass through – much as sunlight is dimmed by clouds in our atmosphere. Such absorption features provide a means of probing the structure of the interstellar medium. In particular, by observing several stars which are located along almost the same line-of-sight in the plane of the sky, it is possible to separate out different cloud components and their locations relative to the stars in the cluster.

This technique is illustrated in Fig. 1 which shows UHRF spectra obtained for three stars which are located along almost the same line-of-sight as seen in the plane of the sky. From the stellar parallaxes it is known that of the three stars, 22 Sco is located closest to us while *o* Sco is located furthest away. The sodium absorption features at wavelengths near 5986 Å clearly show an increasing number of absorption components and stronger absorption with greater depth through the gas clouds. Similar sequences are also seen for other groups of stars lying along similar lines-of-sight in the cluster.

From data such as these, we can build up an accurate picture of the relative positions of the stars in the ρ Oph region and the relative numbers of cloud components in front of each star. To do this requires detailed line profile analysis. The spectral profiles obtained from sodium (and other elements) provide considerable information on the physical conditions in the absorbing regions and these provide valuable input for models of interstellar shocks and other mechanisms thought to be responsible for the formation of the gas clouds.

The technique of using stellar parallaxes together with high resolution optical spectroscopy provides a powerful new tool for probing three-dimensional structure within the interstellar medium. Previous high resolution studies have been confined to measurements in the plane of the sky and have been hampered by the lack of information on distances to the background stars used to probe interstellar absorption line profiles.

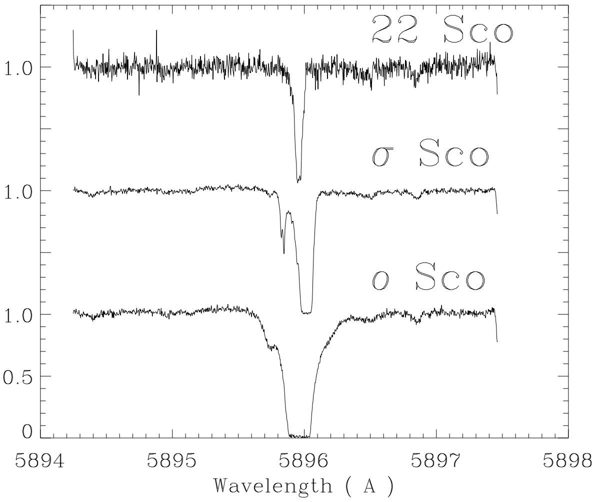

Fig. 1: UHRF spectra towards three stars in the Rho Ophiuchus star cluster which is embedded in an interstellar cloud. The stars are located along almost the same line-of-sight as seen in the plane of the sky but are plotted in order of increasing distance. The spectra show Na I absorption, and clearly show an increase in the number of discrete absorption components with greater depth through the interstellar cloud.

THE BIZARRE X-RAY BINARY CIRCINUS X-1

Helen Johnston (AAO), Kinwah Wu (Sydney), Rob Fender (Amsterdam)

Cir X-1 is one of the most peculiar X-ray binaries known. Some of its characteristics — the long orbital period and periodic X-ray activity — are typical of a high-mass system in an eccentric orbit, while others — the variability of the optical emission, the faintness of the optical counterpart, and several of its X-ray characteristics — suggest that the companion is a low-mass star.

Since its discovery in early 1970s, Cir X-1 has been studied intensively at many wavelengths. The X-ray properties of Cir X-1 were found to differ dramatically each time it was observed, though an underlying 16.6 d period was found. Radio flares were found to occur regularly, at the same interval of 16.6 d, so this probably represents the orbital period of the binary. Type I X-ray bursts were seen, so the primary must be a neutron star. Recently, radio jets were also discovered, making Cir X-1 a virtual twin of SS 433, another binary jet source. And to complete the catalogue of interesting features, Cir X-1 is located about 25 arc minutes from the centre of the supernova remnant G321.9–0.3. This suggests that the system may be a young (< 10^5 yr old) runaway system from a supernova explosion.

To explain the peculiar nature of the X-ray variations within the 16.6 d orbital period, the orbit must be highly eccentric. Depending on the assumed mass of the companion, the eccentricity must be 0.7 (for a massive star) or > 0.9 (for a subgiant of about 3 solar masses). The implied eccentricity for Cir X-1 is the highest of any known binary, which makes it a very special case. Existing theories of mass transfer in close binaries are based on the assumption of zero eccentricity. For large eccentricity, mass transfer occurs only near periastron and ceases at most orbital phases. Within each orbit cycle, an accretion disk is formed, becomes steady and is then disrupted by tidal interaction (Fig. 1).

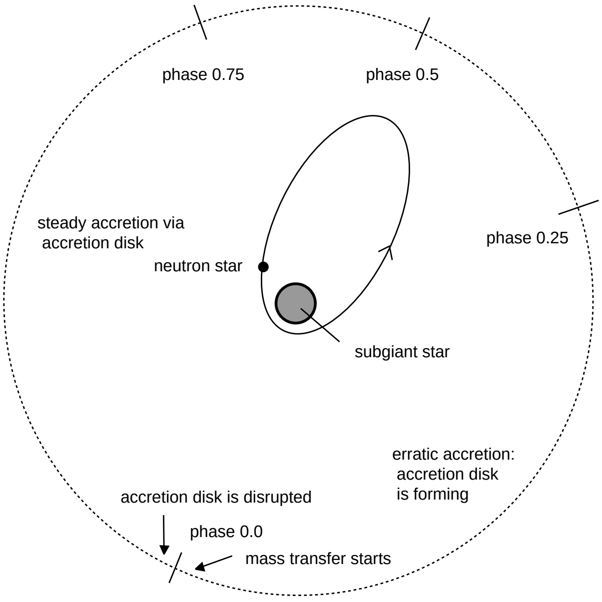

Fig. 1: Model for Cir X-1. During periastron (phase 0) the neutron star passes its closest to the companion and the disk is disrupted, resulting in large X-ray fluctuations. After periastron passage, an accretion disk begins to form; mass accretion steadies, until after apastron (phase 0.5) steady accretion via a disk takes place. Tidal interactions begin to disrupt the disk again as periastron approaches.

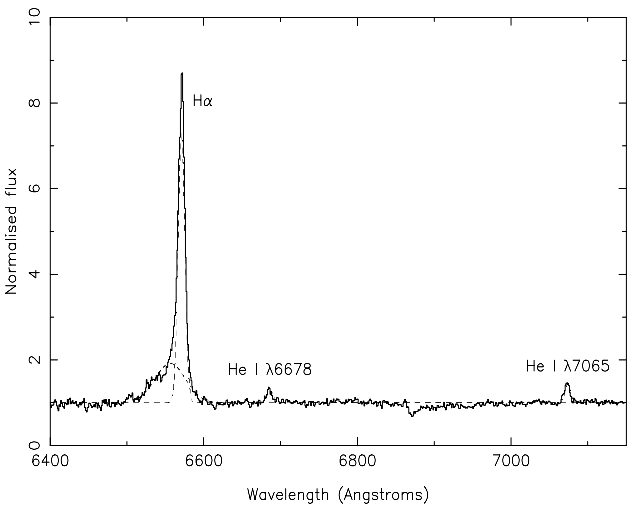

Fig. 2: Spectrum of Cir X-1 taken near apastron on the AAT in June 1997. The spectrum is a sum of 5x1800s exposures. The thin lines show Gaussian fits to the line profiles.

Little is known about the optical spectroscopic properties of Cir X-1. In the IR bands, Cir X-1 is relatively bright (J = 13), but it is faint in the optical (B ~ 20). The first optical spectrum showed a strong Hα emission line. It was later found that the spectrum contained contributions from Cir X-1 and two other near-by unresolved field stars (d ~ 1.5"). Cir X-1 was observed spectroscopically again in 1992, with the system and the two nearby stars resolved (Duncan et al. 1993), at orbital phase 0.75. The Hα emission line was still present but weaker than in the earlier spectrum.

In June 1997 we obtained spectra of Cir X-1 near apastron using the RGO spectrograph (Fig. 2). The spectra were taken in ~1" seeing, so the signal-to-noise of the resultant spectra was limited by the light from the neighbouring stars. Nonetheless, the summed spectrum clearly shows emission lines of Hα and He I λ6678, and He I λ7065. The Hα line also shows a broad component which is shifted blueward from the narrow lines. Gaussian fits to the line profiles show that the narrow lines all have the same velocity (+375 kms^{-1}) and width (~ 9.5Å, or 400 kms^{-1}), while the broad component has a very different velocity (–300 kms^{-1}, or –670 kms^{-1} with respect to the narrow lines) and width (46Å, or 2100 kms^{-1}). The two sets of lines probably arise in very different parts of the orbit, with the broad Hα line probably arising from the accreting matter near the neutron star, while the narrow lines arise near the companion star.

A spectrum taken near periastron by HST (Mignani et al. 1997) also found a strongly asymmetric line profile, but with the broad component at a very different velocity, near 0 kms^{-1}. The difference between the two may represent the orbital motion of the neutron star, with the high velocity of the narrow lines representing the velocity of the binary. This strengthens the case for association with the nearby supernova remnant, and hence for the youth of the system.

Cir X-1 may be a unique object, a low-mass X-ray binary which is so young that the orbit has not yet circularised. Clearly we need to follow the evolution of the spectrum around the orbit. We were foiled by the weather last year in our attempt to get a spectrum near periastron; we will try again this semester.

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HERE THERE BE DWARFS

Steve Phillipps, Bryn Jones (Bristol),
Simon Driver, Warrick Couch (UNSW),
Rodney Smith (Cardiff)

In the last few years we have accumulated deep CCD imaging for a number of rich clusters of galaxies at low to moderate redshifts ($z < 0.3$). The main aim has been to determine, as accurately as possible, the shape of the faint end of the clusters' luminosity functions (LFs). The consensus of this work, and that of other groups carrying out similar surveys, is that the LFs generally have an upturn to a steep slope at faint absolute magnitudes (see e.g. Smith et al. 1997). Nevertheless, individual clusters do clearly differ in the shape of their overall LF, in particular having more or less prominent faint end turn-ups. One simple interpretation for this is as a difference in the relative numbers of dwarf to giant galaxies, while both the giants and the dwarfs have a fixed characteristic shape for their LF ('flat' for giants, 'steep' for dwarfs). We can then characterise the overall LF shape by the 'dwarf-to-giant ratio' or DGR. We quantify this as the ratio of the number of galaxies with absolute R magnitude between –16.5 and –19.5 to those brighter than –19.5 (for a Hubble constant of 50 kms^{-1} Mpc^{-1}). For a 'standard' shaped LF with Schechter slope $\alpha \sim -1$, the DGR takes a value close to 1. As any faint end turn up becomes more prominent, clearly the DGR rises. (For instance a pure Schechter function with a steep slope $\alpha \sim -1.5$ would have a DGR around 5).

From our overall data set, and with some hints from elsewhere, we have been able to explore how the LF, or the DGR, varies with cluster characteristics. For instance, looking at morphologically very similar clusters (basically Coma look-alikes) showed little or no evidence for a change in LF shape with redshift or look-back time, at least over the range we have covered. On the other hand, it appeared that it was the morphologically least compact or regular (e.g. late Bautz-Morgan type) clusters which had the most impressive dwarf populations. Furthermore, study of individual clusters revealed that the DGR generally increased outwards, that is the dwarf population was more spatially spread out than the giant population (which primarily defines the cluster core).

The obvious synthesis of these results is to suppose that the DGR rises as the local density (of giants) falls. The central parts of the most compact clusters have the smallest fraction of dwarfs, while the less dense clusters and the outer parts of the compact clusters have more. This is illustrated in Figure 1 (from Phillipps et al. 1998). The filled symbols represent the central parts of various Abell clusters (specifically the central 1 Mpc^2 area in projection) and the open symbols the outer parts of these clusters. The triangles show the run of DGR with radius for one individual cluster, A2554 (Smith et al. 1997). Particularly interesting is the overlap region where the outskirts of compact clusters and the central regions of loose clusters have the same projected galaxy densities *and* the same DGRs. This again seems to suggest that local density is the important physical parameter. All this is not to say that dwarfs necessarily *avoid* dense regions. After all they clearly exist in the centres of the clusters (at least in projection) and, indeed, their number densities do rise (slowly) towards the cluster centres. However, it is very apparent that there are many more dwarfs per giant (or equivalently a bigger fraction of total galaxy mass is in dwarfs) in lower density environments.

This relationship between the dwarf population and the local density thus appears to parallel the well known morphology–density relation, wherein the densest

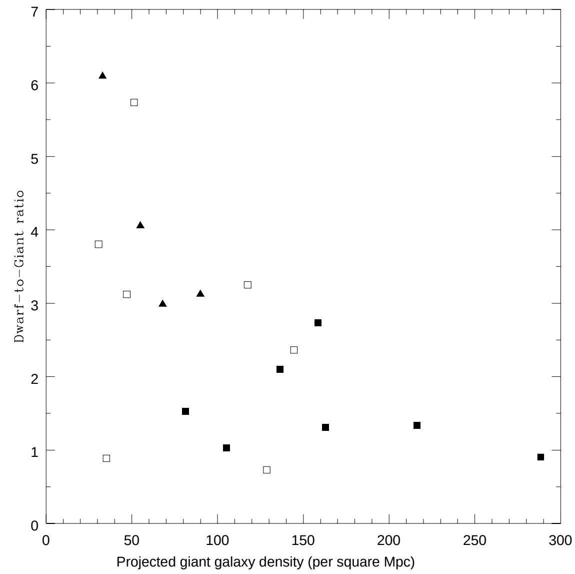

Figure 1: Dwarf to giant ratio as a function of local density.

regions have the largest fraction of early type galaxies and the lowest density regions contain mostly spirals. Putting the two together means, of course, that our dwarf galaxies tend to follow the more dispersed distribution of the spirals, not the very clustered distribution of ellipticals. We might speculate, too, that the two relationships have a similar origin, possibly within the hierarchical clustering schemes which appear to be successful in generating the morphology–density relation among giants.

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AN OPTICAL IDENTIFICATION PROGRAM OF FAINT ASCA SOURCES: DISCOVERY OF A TYPE II AGN AT Z=0.67

B.J. Boyle (AAO), O. Almaini (Edinburgh), I. Georgantopoulos (Athens), R. Griffiths (Pittsburgh), T. Shanks, K. Gunn (Durham), G. Stewart, A. Blair (Leicester)

Over the past year, we have been using LDSS on the AAT to conduct an optical identification programme of faint X-ray sources detected with the ASCA X-ray satellite. ASCA has an effective passband of 1–10 keV (12.4 Å–1.24 Å) and is therefore sensitive to more energetic X-ray wavelengths than previous X-ray imaging missions such as ROSAT (0.5–2 keV) and Einstein (0.3–3.5 keV). The energy range sampled by ASCA is also closer to the peak in the X-ray background (~30 keV) than previous X-ray missions.

The ROSAT mission has been able to resolve up to 70% of the 0.5–2 keV or 'soft' X-ray background into discrete sources. Ground-based optical identification programmes have shown that the bulk of the sources are QSOs. Some debate still exists over the nature of the 'narrow-emission-line' galaxies (NELGs) identified in increasingly large numbers at faint X-ray fluxes in these soft surveys. These objects could either be starburst galaxies or Seyfert 2 galaxies (Type II AGN), although most of the NELGs found to date exhibit ambiguous optical spectra, and few definitive examples of either class of object have been found to date. These objects could, in principle, comprise much of the remainder of the soft X-ray background, and their X-ray spectra are consistent with the spectrum of the unresolved X-ray background. If these sources are to make up a significant fraction of the X-ray background at harder energies, then they should show up in increasing numbers in ASCA observations.

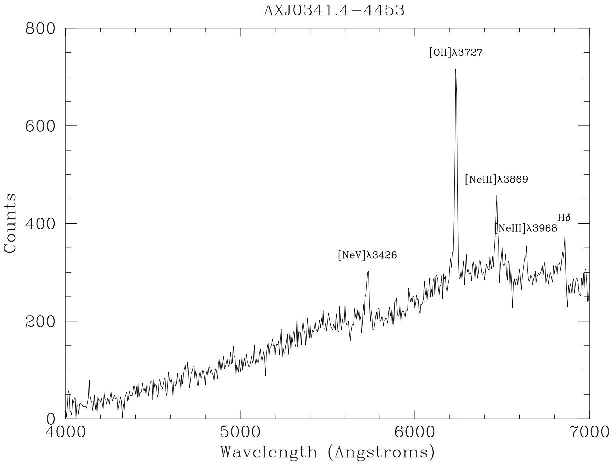

Figure 1: LDSS spectrum of AXJ0341.4–4453.

It was this class of object that we hoped to find in our ASCA source identification programme. We selected optical counterparts to the ~40 faint ASCA sources detected in 5 deep fields by cross-correlating the ASCA source positions with data we had previously obtained with the ROSAT mission. This decreased the uncertainty in the X-ray source position from ~1 arcminute to 10 arcseconds. Optical counterparts were then selected from UK Schmidt/AAT photographic plates of these areas. We obtained spectroscopic identifications for many of these optical counterparts over two observing seasons (November 1996 and September 1997) using LDSS on the AAT. Combined with earlier observations from an AUTOFIB identification programme of the original ROSAT sources, we now have a spectroscopic identification for over 80% of the sample. Over 80% of the identified sources are QSOs which undergo strong cosmological evolution in the 2–10 keV passband between z=0 and z=2. One object, AXJ0341.4–4453, identified in the September 1997 observations, however, immediately drew our attention. It is one of the hardest X-ray sources in the sample, with a spectral index indicating a flat or inverted spectrum over the range 1–10 keV. Its optical spectrum is clearly that of a z=0.67 Seyfert 2 galaxy (see figure 1). Only one other Seyfert 2 has been identified by ASCA at cosmological redshifts (z=0.9), as part of a deep survey by Ohta et al. (AXJ08494+4454).

The X-ray spectrum of this object is consistent with an absorption column of $N_H \sim 10^{22}$ cm^{-2}. The implied amount of gas and dust is more than sufficient to obscure the broad line region in this object. AXJ0341.4–4453 and AXJ08494+4454 are now the two best examples of hard X-ray sources shown to be Type II AGN at moderate to high redshift. The discovery of Type II AGN amongst faint ASCA sources was predicted from models in which the bulk of the X-ray background originates from AGN, with varying amounts of internal absorption. The identification of AXJ0341.4–4453 confirms that Type II AGN are present in hard X-ray-selected source lists. Such objects should also be detected at far-infrared (ISO) or sub-millimetre (SCUBA) wavelengths. Observations with the next generation of hard X-ray imaging missions (AXAF, XMM) should reveal whether they do indeed comprise the bulk of the faint X-ray source population at energies greater than 2 keV.

SN 1987A: THE NEXT BANG

Ray Stathakis, Russell Cannon (AAO), Megan Callaghan (AAO/Newcastle), Matthew Kenworthy (IoA), Peter Meikle and Alexandra Fassia (IC).

More than a decade after the discovery of supernova explosion SN 1987A, astronomers are anxiously awaiting a second impact. The supernova is surrounded by a complex circumstellar ring system, well known from the spectacular HST WFPC image (Figure 1). The origin of this system has been explained as the interaction of a slow dense stellar wind during the progenitor's red supergiant phase, and a fast low-density stellar wind from the later blue supergiant phase (e.g. Lunqvist & Fransson 1996). An alternative theory explains the structure by the merger of a long-gone binary companion (e.g. Podsiadlowski 1992). It is the collision between the expanding ejecta and the circumstellar media (CSM) that is expected to produce a second dramatic display.

Predictions of when the collision will occur and what we shall see vary widely, due to uncertainties in the extent and shape of both the ejecta and the CSM. In the first spectral observations of SN 1987A, blueshifts as high as 30,000 kms^{-1} were measured, with significant mass travelling at 15,000 kms^{-1}. The radius of the bright inner ring of the CSM ring is about 0.65 arcsec, which at 50 kpc corresponds to 0.52 light year, so in a simplistic model the collision of the bulk of the material would start 10 years after core collapse. More recent observations have shown that the outer edge of the ejected envelope has slowed down after plowing into thinner material inside the ring, introducing a delay of up to a further ten years before impact with the bright ring (e.g. Gaensler et al. 1997).

While this date is still remote, we already see evidence of collision with CSM inside the ring. After only three years, radio emission was detected, showing that the outermost material of the ejecta had started running into circumstellar material. This radio emission has continued to rise, and superresolved radio images (Gaensler et al. 1997) taken from 1992 to 1995 show an asymmetric shell, brighter on the eastern and western edges. HST images showed a brightening of the ring in an arc around P.A. 206 (SSW) in February 1996 (Garnavich & Kirshner 1996) and a hot spot with blueshifted emission appeared at P.A. 29 (NNE) just inside the bright ring in April 1997 (Pun et al. 1997; Garnavich, Kirshner & Challis 1997A,B).

The structure of the ejecta.

In order to understand these observations, and to predict future changes, we need accurate models for the structure of the CSM and the supernova ejecta. This object has been more closely monitored than any previous supernova event, but there is much work still to do in assembling all the evidence and constructing a consistent model.

Observations of spectral line profiles of emission lines from SN 1987A made at the AAT during the first two years after core collapse can help to define the shape of the ejecta as they map the envelope along the line of sight. During this period the outer layers became increasingly transparent, revealing the inner regions of the supernova. Emission lines from hydrogen, oxygen, calcium, carbon and iron were observed at high S/N and resolution using the RGO spectrograph and UCLES (e.g. Figure 2).

Analysis of the variation between line profiles and evolution with time was carried out by Stathakis (1996). A number of distinct emission regions were identified. The innermost region, travelling at between 150 kms^{-1} and 1050 kms^{-1}, is homogeneous and shows evidence of strong mixing between the hydrogen of the outer layer and iron from the core. A narrow boundary region with velocities between 1050 kms^{-1} and 1400 kms^{-1} has quite different characteristics. It is strongest in forbidden oxygen and carbon emission, and is clumped.

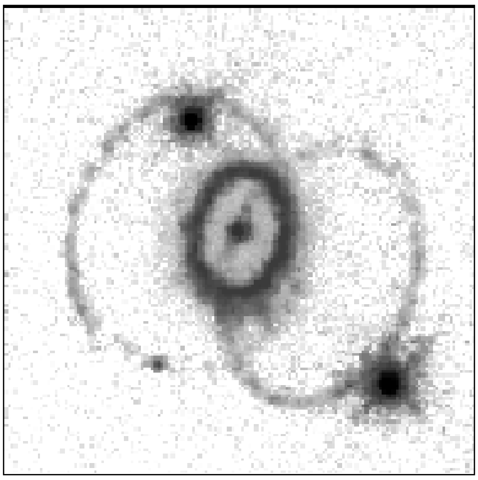

Figure 1: The complex system of CSM rings observed using HST WFPC (copyright STScI 1994).

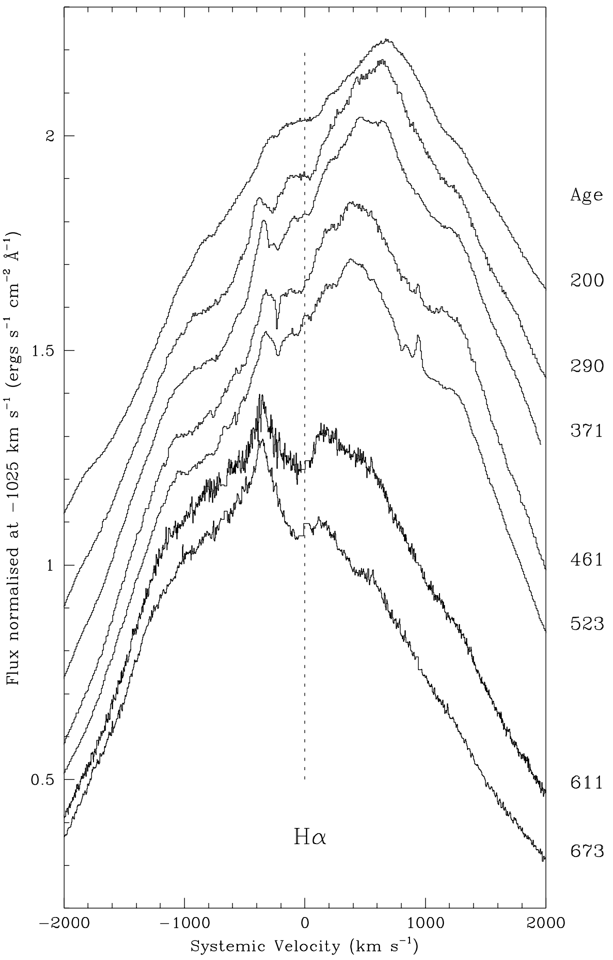

Figure 2: The evolution of the H alpha emission line profile observed at the AAT. The excess redshifted emission is strongest relative to the rest of the line around day 371 and disappears around day 600 due to dust formation in the envelope.

Comparison with spectropolarimetric observations (Cropper et al. 1987; Chugai 1992) suggest a structure as shown in Figure 3, with extensions along the axes at P.A. 200 (SSW) and 280 (W). In this model a series of collisions with the CSM are expected, and calculations assuming a spherically-symmetric envelope will considerably underestimate the time of impact for the most extended regions. It is interesting to note that early signs of collision are consistent with significant axes aligned SSW/NNE and E/W.

Current Projects

Spectropolarimetric observations are important in defining axes of symmetry and the extent of asymmetry of the supernova envelope. Stathakis and Callaghan are reexamining the later epochs of spectropolarimetry observed at the AAT by Bailey and Cannon on the RGO Spectrograph with the Pockels Cell Modulator. These epochs cover a period of dust formation in the ejecta, and evolution of the polarisation characteristics will help constrain models of the envelope and dust formation.

Two observational projects have been carried out recently at the AAT to search for signs of impact and to produce baseline observations for comparison with later epochs. In both cases innovative instruments were used to do ‘integral field spectroscopy’, i.e. simultaneous spectroscopy of many spatial pixels covering an extended object. Although we cannot compete with HST for spatial resolution, ground-based data can be useful, since larger telescopes can yield higher S/N spectra.

Optical spectra around Hα were obtained using the Phase I version of SPIRAL (AAO Newsletter **81**, 11) by Kenworthy, Cannon and Stathakis in November 1997. The weather was excellent, with subarcsec seeing. Data processing is continuing, but early results show a blueshifted extension of Hα to the south of the supernova. This is an exciting result and demonstrates the potential of SPIRAL.

A month later, Meikle, Fassia, Cannon and Stathakis made spatially resolved observations with the Max Planck imaging spectrograph, 3D. Preliminary results indicate narrow lines (< 300 kms^{-1} width) of Brγ, He I 2.058 μm and [Fe II] 1.64 μm . The [Fe II] line was bright enough to map its spatial distribution. It appears to be extended along the E-W axis. Work is in progress to locate the origin of this emission, which appears to peak slightly south of the supernova. Further 3D observations are planned.

Database on the web

A database of observations of SN 1987A taken at the AAT has been released on the web. The address is http://www.aao.gov.au/local/www/sne/SN1987A.html. The

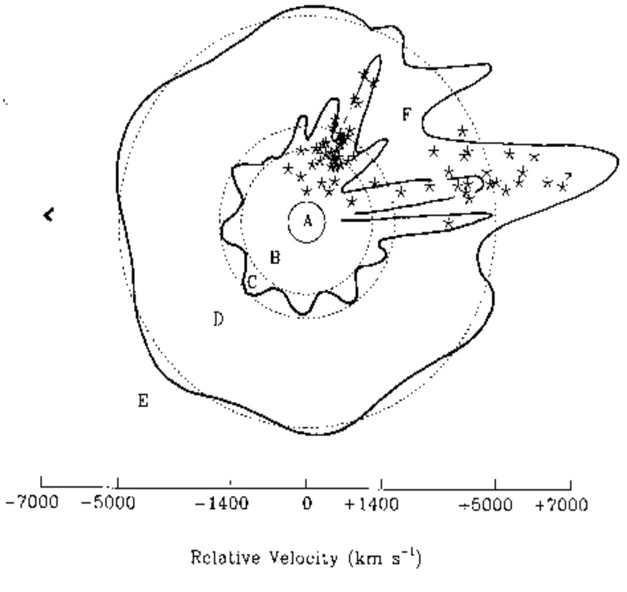

Figure 3: A suggested model for the structure of the inner regions of the ejecta of SN 1987A. (A) Core; (B) Fe-rich inner region; (C) C-O shell; (D) He Shell; (E) H Shell; (F) disturbed sector.

database includes details of available observations and requests are welcome. As effort becomes available, data will become directly accessible in FITS and ascii format. Ninety percent of all observations of SN 1987A were taken during the first two years. These data will be complete with the addition of the spectropolarimetry data currently being processed by Stathakis and Callaghan. Samples of later epochs are available in preliminary form on request. All unprocessed data more than two years old are also available. Send requests to ras@aaocbn.aao.gov.au.

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LDSS++ — NEW ULTRA-HIGH PERFORMANCE RED SPECTROSCOPY FOR THE AAT (or How To implement Six Impossible Ideas before July...)

Karl Glazebrook and the LDSS++ team (JBH, KT, TJF, LGW, AL)

The LDSS instrument on the AAT pioneered the early work on high-redshift galaxies: the survey of Colless et al. (1991) was the first to take spectra of significant numbers of normal field galaxies at redshifts greater than 0.5. And all this with the pre-CCD era Image Photon Counting System (now a literal museum piece) as the detector!

Since then, more modern multi-slit spectrographs, on better sites, have overtaken LDSS in the high-redshift game. LDSS-2 on the WHT and MOSIS on the CFHT have been used to survey normal galaxies to z~1, and LRIS on the 10m Keck telescope has provided the first spectroscopic confirmations of z~3 U-band dropout objects in the Northern Hubble Deep Field. Meanwhile use of LDSS on the AAT has shrunk, with only 2–4 applications per semester, of which 0–1 get time.

The LDSS++ project was inspired by the forthcoming observations of the Southern Hubble Deep Field, with its exciting potential for high-redshift science, and the realisation that with new technologies and new observational techniques it might be possible to upgrade LDSS and improve its performance by an order of magnitude. The spectroscopic performance will be competitive with the larger Keck telescope, at a cost to the observatory of less than $50,000.

Despite some of the technologies involved being at an early stage, we felt that it was worth taking a risk on forging ahead, so the old LDSS is in pieces and the LDSS++ project is underway. We anticipate that all the developments we describe below will be in place by July 1998, when we have 4 nights of Director’s time to commission LDSS++ and take some test observations of HDF-S.

The Universe through a Rosy-Coloured Spectrograph

We are targeting LDSS++ to the 5000–10000 Å wavelength regime, highly optimal for studying field galaxies at z~1 (and not so bad for low redshift galaxies either, given the wavelength of Hα!). The region longwards of 8000 Å has traditionally been neglected for astronomical spectroscopy, because of the forest of bright OH lines and the falling response of detector and optics throughput in existing spectrographs.

However with LDSS++ we believe we can deliver outrageously good performance in this regime (see below). Studying galaxies with z>1 has prompted the development of several near-IR J and H band spectrographs (e.g. COHSI which will be commissioned on UKIRT in March 1998), but there the OH forest is even worse. By optimising for the RIZ optical bands, we can still get superior spectra out to z=1.7, without going to IR technologies.

How to Build the World's Most Efficient Spectrograph

Typically, efficient spectrographs deliver total efficiencies (photons detected/photons incident) of around 20–30%. This reflects progressive losses from the primary mirror, the spectrograph optics, the grating or grism and the quantum efficiency of the detector. While we can do nothing about the primary mirror (85% typical reflectivity), with LDSS++ we aim to significantly improve all other components:

(i) Spectrograph optics: The current LDSS optics have Anti-Reflection coatings optimised for 3700–7500 Å. Beyond this they fall rapidly. However, with modern dielectric coatings it is possible to maintain optimally high throughput over the entire 6000–10000 Å range. The LDSS++ plan is to recoat all 18 air-glass surfaces in the camera and the collimator to deliver this performance.

(ii) Grism: In collaboration with Sam Barden at NOAO and Kaiser Optical Systems Inc. of Michigan we plan to fit LDSS with a Volume-Phase Holographic grating (or VPH for short). While it sounds like something from Star Trek, the concept is relatively simple: the rulings which disperse the light are embedded in the body of

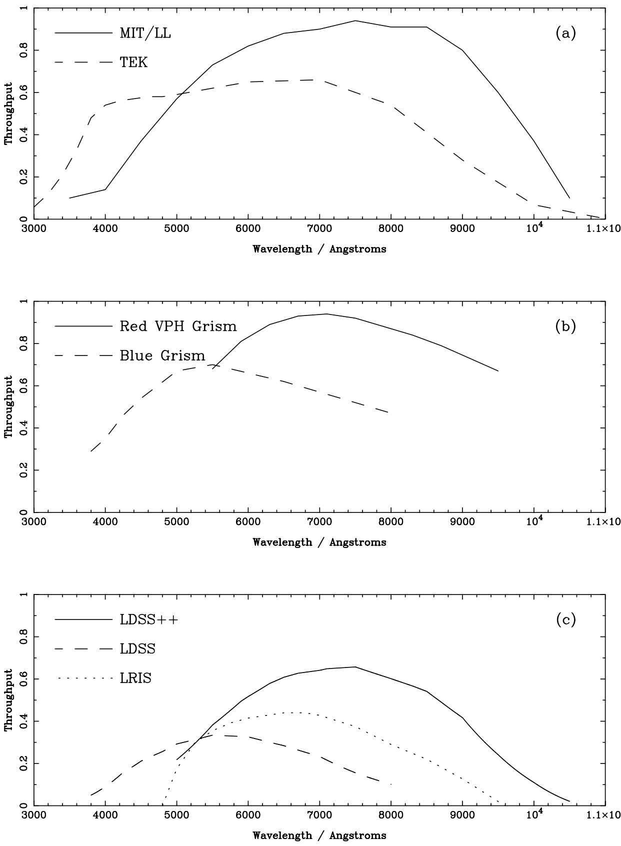

Figure 1. Performance improvements for LDSS++. *(a)* A comparison of the existing TEK 1024x1024 CCD with a MIT/LL 4096x2048 Deep Depletion CCD. *(b)* Comparison of the existing medium-blue grism with the red VPH grism. *(c)* Total system throughput (excluding primary mirror), old and after the upgrade including a projection of the new coating performance. We also show for comparison the performance of Keck's LRIS in its most efficient configuration (150 lines/mm grating blazed at 7500 Å) for comparison.

the material rather than scratched on the surface as in conventional technology. Laser interference is used to form these rulings photographically, hence the name. Because the dispersive efficiency is much higher, less light is reflected back and wasted, giving the very high throughput (Figure 1*(b)*). At the blaze wavelength a VPH grating gives 94% throughput, compared to about 67% for the current LDSS blue grism. We will blaze the VPH at 7000 Å (400 lines/mm) to maximise the red performance for z=1 objects, as described below. This will be the first use of a VPH grating in a low-resolution spectrograph designed for redshift work.

(iii) CCD: The AAO is a member of the MIT/Lincoln-Labs CCD consortium, which has already delivered us a useful 2048x4096 engineering device. These have a very good red QE – 90% at 7000 Å, compared to 66% for the current TEK 1024x1024 chip. While this is already a significant gain, AAO hopes to acquire a deep depletion device which sustains the QE to even redder wavelengths – it could be as good as 37% at 1 μm! (See Figure 1*(a)*.)

Combining these three factors provides significant improvements – as shown in Figure 1(c). The peak system throughput is improved by a factor of two – 66% at 7500 Å excluding the primary mirror. This is what comes from a >90% efficient grism and a >90% efficient CCD. Moreover, the high efficiency is sustained all the way out to 10000 Å. This would certainly make it the world's most efficient astronomical spectrograph.

Performance Predictions for LDSS++

We have folded in all these theoretical gains to make some simulated spectra of future faint LDSS++ observations. We take template Kennicutt spectra of representative galaxy types, redshift them, normalise to a given observed magnitude and add Poisson object+sky noise. These are shown in Figure 2 representing a 30,000 sec exposure (which would increase by 4 if using the technique mentioned in the next section). It can be seen that reasonable continuum detections (S/N=5 per pixel) are possible for z=1 objects at R=24, I=23. For emission line objects, it is possible to reach R=25, I=24. *Note*: the median redshift for field galaxies will be about z=0.7 at I=23 and z=0.9 at I=24, depending on the evolutionary model.

Realistic instrument parameters are put in. With the red VPH grism and MIT/LL CCD described above, we will get 2.46 Å/pixel and 5000 Å of wavelength coverage. With the LDSS optics resolution of 50 μm we will get a minimum resolution of 3.3 pixels, or 8 Å FWHM. The smaller MIT/LL pixels result in rather better sampling. We assume a 1" slit which gives 10 Å FWHM, and that 70% of the galaxies light lands in the slit.

How do these figures compare with previous surveys? The LDSS2 survey was limited at B=24 (equivalent to R=23) and the CFRS survey (using MOSIS) went to I=22. This was with similar exposure times on a 4m telescope. The LDSS++ performance increase allows us to go a magnitude fainter than previous 4m surveys. Using the Keck, follow-up observations of Lyman break galaxies (selected by their U-band drop-outs) have spectroscopically confirmed targets in the R=24–25 regime, with similar S/N as the LDSS++ simulations in Figure 2.

We can also compare instruments: LRIS on the 10m Keck telescope is a state-of-the-art multislit device with modern coatings – the peak system efficiency is 45% (excluding the primary mirror) with conventional Milton Roy reflection gratings and a TEK 2048x2048 CCD. The best that can be delivered at 9500 Å is 6%, compared to 24% for the most favourable projections for LDSS++. Thus at 9500 Å the AAT would detect half as many photons as the Keck, despite having only 1/7th the collecting area!

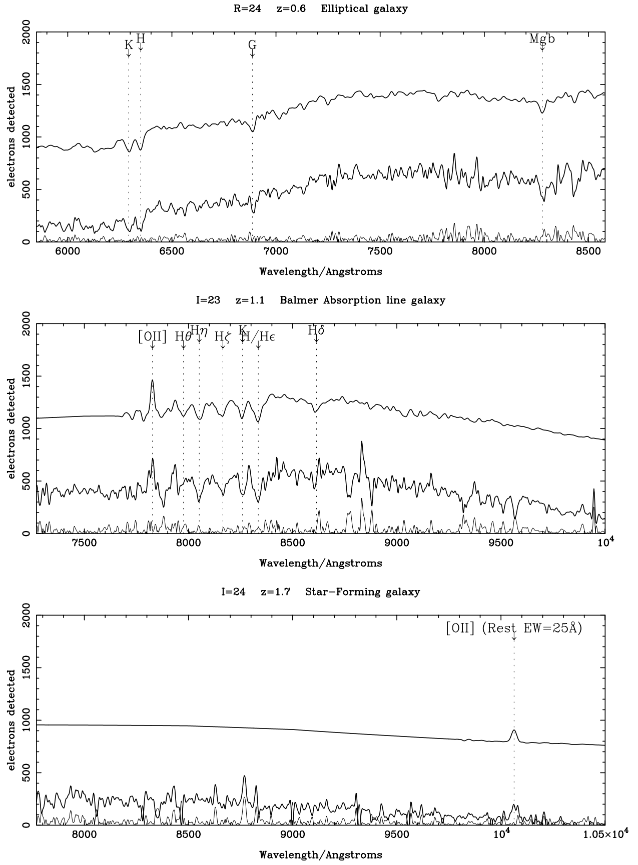

Figure 2. Some simulations of spectra observed through LDSS++ (30,000 seconds exposure). In each panel the upper curve is the noise-free input spectrum (multiplied by the throughput), the middle curve is the observed spectrum, with noise added and optimally smoothed, and the lower curve shows the Poisson noise spectrum. The latter contains numerous spikes from the bright OH lines.

How to observe 300 objects

With LDSS++ we also plan to commission a new way of observing with multi-slit masks, using micro-slits and charge-shuffling. AAO Newsletter #75 describes the key charge-shuffling concepts, developed at AAO and now routinely used with TAURUS. In brief, charge-shuffling allows images on the CCD to be moved electronically on the CCD *without* reading out – and thus incurring the readout noise penalty.

The new idea for LDSS++ is simple: synchronise charge-shuffling with object-sky telescope nodding to allow the *simultaneous* determination of the sky frame through the *same* slits – see the cover picture for an illustration of this concept. We envisage doing this perhaps every minute during a long integration. This will of course give superb sky-subtraction, even with multi-slits which typically have ragged edges. (See AAO Newsletter #79 for more details on this concept, in the context of the RGO spectrograph). Furthermore the MIT/LL chip is so large (4096 pixels spatially) we can shuffle a full 9 arcmin field.

This has an important consequence: we do not need a long slit for sky-subtraction. In traditional multi-slit systems we typically have a 10" slit on a 1" object. Most of the detector area is wasted on sky and normally only 30 objects are observed at once. In contrast, with charge-shuffling we can use small 1" long micro-slits. Thus we can cram up to 500 of them on the detector*.

There is a penalty of course: sqrt(2) more sky noise and half the time is spent on the sky frame – this means one has to go four times longer to get the same S/N. But once one has done this one has 10–15 times as many objects. And of course, virtually perfect sky subtraction, which comes in handy when observing objects 1% of the sky brightness in the OH forest!

The trick of course is to go faint enough that the surface density of targets is high enough. With the above performance increases, we anticipate typical limiting magnitudes for objects of about R=24 or I=23. At this magnitude there are 40,000 galaxies per sq deg per mag, or about 300 in a typical 3'x9' LDSS slit area, which matches very well on to 1" micro-slits.

For brighter objects and less crowded fields, micro-slits and charge-shuffling offer no theoretical gain, but the huge gain in sky-subtraction would probably be of considerable practical benefit to many projects, despite the cost in observing time.

If we were to fold in the extra multiplex advantage of this technique (admittedly a somewhat dubious comparison) then the AAT/LDSS++ would be marginally *ahead* of Keck/LRIS in galaxy photons per unit time.

Finally, we expect this technique to be even more useful with the next generation of 8m telescopes and optical/near-IR multi-slit spectrographs. As one goes to fainter magnitudes, higher redshifts and into the OH rich J and H bands, the ability to handle very crowded fields and do accurate sky-subtraction becomes critical. There may be an IR analogue of charge-shuffling (Glazebrook et al., in preparation).

Evil Plans for the Southern Hubble Deep Field

AAO proposes to use LDSS++ to carry out a large redshift survey in the Southern Hubble Deep Field, which will be observed by Hubble in October 1998. Since there as yet no large 8m or greater telescopes in the south this probably represents the only possibility for getting significant numbers of redshifts. LDSS++ is extremely well-matched – micro-slits are ideal for the tiny Hubble field size.

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*As part of the LDSS++ upgrade we intend to find a way of getting multi-slit masks to be made in Australia, with consequent speed up of the turnaround time.

For the kinds of morphological and evolutionary analysis people are interested in doing, redshifts are a pre-requisite. In the spirit of the Public Domain nature of the HDF observations AAO will immediately release all the spectra and redshifts into the public domain as soon as the data is reduced.

We hope to start this project during LDSS++ commissioning in July 1998, with possible further observations in August and September and in 1999.

Further LDSS++ science

Of course the possibilities for LDSS++ science do not stop with redshifts in the HDF. One can imagine many kinds of other projects: some random examples are:

(i) TTF follow-up: The TAURUS Tunable Filter has been used very successfully on the AAT to find many hitherto undetectable weak emission line sources. Examples include: Ly-α blobs around z=4 QSOs, Hα sources in z~0.5 clusters, [O II] sources in z=1 field and cluster surveys. LDSS++ has a similar field of view to TAURUS and is well suited to follow-up – emission lines can be confirmed spectroscopically down to R=25, I=24 as shown in Figure 2.

(ii) Star-formation at z=0.5: The Northern HDF redshift measurements, together with the z<1 surveys mentioned above, have posed an interesting picture of possible evolution of the SFR of the Universe with the possibility of a peak at z=1.5, dropping off at z<1 and z>2. These rates are estimated using UV continuum fluxes of the galaxies. But a realistic understanding depends on better measurements. With LDSS++ we can track Hα in the optical to z=0.5, and directly measure the evolution in SFR with a better understood and less dust-affected measure. We can also spectroscopically confirm redshifts via [O II] (and estimate SFRs) out to z=1.7, the redshift of the supposed peak.

(iii) SFR in clusters vs the field: It is known from the Butcher-Oemler effect that clusters have enhanced SFR at z=0.5 than at z=0. Tracking this directly, with Hα measurements, and comparing with the field provides powerful constraints on cluster and galaxy formation in hierarchical clustering models. Clusters are especially suited to the micro-slit approach due to their crowded fields.

(iv) Redshift space distortions: At z=1 these provide a very clear signature of Ω (Kaiser et al.). The trick is to map enough galaxies in a z=1 cluster. The TTF/LDSS++ synergy would allow one to efficiently pick out candidates against the background wall of galaxies and confirm the redshift spectroscopically.

(v) General spectroscopy: One should note that LDSS++ has 10 times the throughput of 2dF and 5 times that of the RGO spectrograph. For all low-resolution red observations it should be the spectrograph of choice, even for single object work!

(vi) Deep Imaging: Without charge-shuffling LDSS delivers a 12' FOV (slightly larger than TAURUS), *all* of which is accessible with the MIT/LL CCD (unlike the TEK). LDSS++ imaging would have a system efficiency of 61% at R, or 31% at 9500 Å.

And Finally...

It should be noted that, at the time of writing, none of this has actually been realised, though the funding has been approved and the wheels are in motion. It is a somewhat risky endeavour: Sir Humphrey might describe it as a “very brave idea”.

LDSS++ is due to be commissioned in July of 1998, so its availability can not be guaranteed for 98B. Even if it all works as advertised we must regard all 1998 (and possibly 1999) observing as shared risks.

LDSS++ will continue to be an expert user instrument for now, though increased demand may result in efforts to remedy this! Prospective observers should contact the Instrument Scientist, Karl Glazebrook (kgb@aaoepp.aao.gov.au) *before* applying for time.

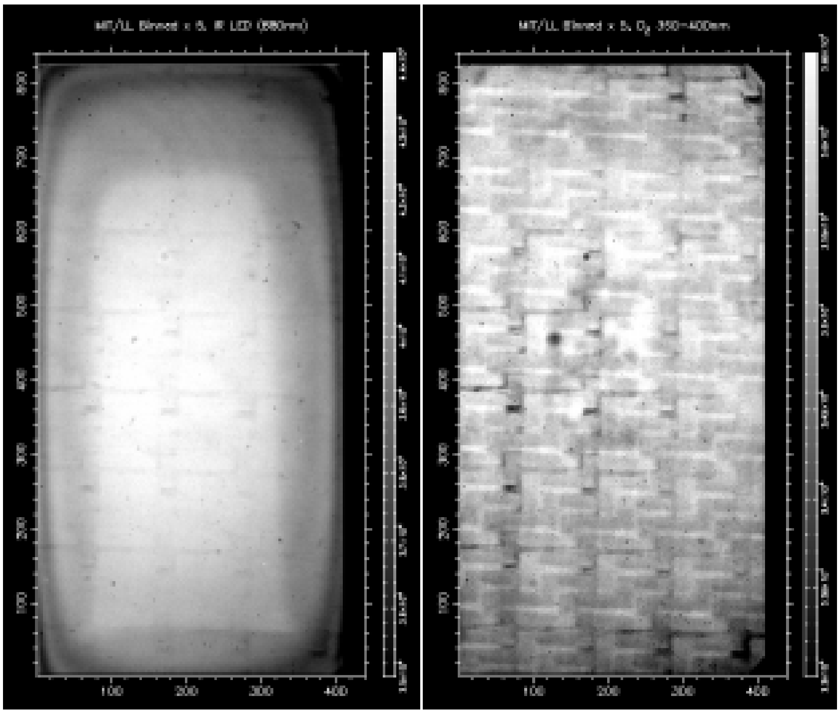
Nevertheless we hope all will go well, and there will be a resurgence of interest in high-redshift spectroscopic science at the AAT.

2K X 4K MIT/LINCOLN LAB ENGINEERING CCD AVAILABLE ON AAT

Chris Tinney

In October 1997, the AAO began commissioning its first large format device for use on the AAT. This is a set-up grade thinned, back-side illuminated device produced as part of the MIT/Lincoln Labs CCD Consortium. The device has 2048 x 4096 15μm pixels, and is run from the AAO-1 CCD Controller system. Due to the outstanding output amplifier performance of these MIT/LL devices, it has been possible to speed up read-out times such that almost 8 times more pixels than our existing 1K CCD can be read out in only twice the current read-times, at similar or better read noises. The table summarises the CCD’s electronic performance.

Full well seems to be about 140 Ke$^-$, but this limit is only reached in the FAST mode – all other modes are limited by the 16-bit A-D at 65535 counts. NONASTRO



Images of flat fields in the red (left; 880 nm) and blue (right; 350—400 nm), showing the brick wall pattern (BW) which dominates at shorter wavelengths.

mode is not available due to the speed of the serial links in the AAO-1 controllers – in any case it would not be recommended for astronomical observations with this device, as it becomes highly non-linear. The next generation of AAO-2 controllers will decrease these read times for large format devices significantly.

These MIT/LL devices have been optimised for maximum sensitivity in the red – with a QE curve peaking at about 80–90% at 6000 Å, but falling to 30% at 4000 Å and almost nothing at 3500 Å. In December 1997, the device was therefore coated with lumogen at Mt Stromlo Observatory, to see whether an improved blue response could be obtained. This coating absorbs photons shortward of 4000 Å, and re-emits them at 5500 Å. Typically such coatings have been seen to produce flat blue responses below 4000 Å, equal to approximately half the QE of the uncoated device at 5500 Å. This suggests a QE of ~35% should be obtained from the lumogen coated MIT/LL, making the coated MIT/LL actually more sensitive than the TEK blueward of 3400 Å. Unfortunately, data to confirm this expectation have yet to be obtained.

Cosmetically, the device shows a few bad columns, and a pattern christened the "brick wall" which is present in all these early MIT/LL devices, and is thought to be due to imperfections in the laser annealing process. This QE pattern is relatively strong in the blue (20% peak-peak at U, 7% peak-peak at B) but weak in the red. The pattern has been found to flat-field out. Fringing is present in the red, but is considerably smaller than that seen in our current TEK CCD.

[illegible]	[illegible]	[illegible]	[illegible] µs/pix)	READ TIME (s) Binning 1x1	2x2	5x5
FAST	2.3	2.9	10.5	95	39	14
NORMAL	1.11	2.0	18	160	45	18
SLOW	0.366	1.45	34	300	93	24
XTRASLOW	0.093	1.3	106	940	260	56

To date this device has been used successfully on the RGO Spectrograph, UCLES and Taurus. In particular, the detector is almost ideal for use with Taurus+TTF. Its small pixels mean that the f/8 system can be used for almost every application. And its large format means that charge shuffling techniques can now be used over the *full 9 arcminute field* of Taurus. Moreover, it has better QE in the red than our current TEK detector. It should now be the detector of choice for all TTF observers. RGO and/or UCLES observers who want long wavelength coverage, smaller pixels and/or to observe in the red should also seriously consider the use of this device. The device will not be available for use at Prime Focus until the Prime Focus Upgrade is completed later this year, and is not compatible with 2dF.

A more complete report of the performance of this detector, complete with updates as its performance is further characterised, can be found at http://www.aao.gov.au/local/www/cgt/ccdimguide/mitll_performance.html.

This detector is available to all observers from Semester 1998A. Observers scheduled in 1998A are urged to examine the detailed report and, if necessary, to consult with their support astronomer or the relevant instrument scientist. If no detector is specified for your programme on the AAT schedule, or if you wish to change detectors, it is vital that you inform the AAT Scheduler (sched@aaoepp.aao.gov.au) as soon as possible.

DATA ON CDROM

Garry Kitley

The AAO will be offering to observers a copy of the archive CDROM/s that includes their data. To clarify, data is not archived to CDROM daily, but whenever there is about 600MB acccumulated. So there are usually several nights' data on one CDROM. However, if there are more than 600MB of data generated during a night, then there would be several CDROMs written for that nights' data. The data is written as disk FITS on an ISO9660 standard CDROM. The cost would be $10 for each CDROM. This offer is for one copy only of the CDROM/s and only if we are notified in advance, i.e. at the latest the day before the data is to be obtained. Send requests to archive@aaocbn.aao.gov.au or contact Ray Stathakis or Garry Kitley.

2DF STATUS REPORT – END OF 1997

Karl Glazebrook, Ian Lewis and Keith Taylor, for the 2dF team.

Semester 97B, which is now drawing to a close, has been the first semester of scheduled 2dF observations. This decision was always a bit of a risk, as the first test of the full 400 fibre two spectrograph system came only at the start of the semester! However, software and hardware development has come along rapidly, and only a minimal amount of scheduled time has been lost to 2dF problems.

Although some work remains to be done (see below), we feel 2dF is now more in an operational mode rather than a commissioning mode – after six years' hard development work it is probably AAO’s greatest achievement. We look forward to many coming years of *routine* operations, the completion of the big galaxy survey, and the other exciting scientific projects long-planned for 2dF.

A consequence of these routine operations will be a departure of this by now regular ‘2dF Progress’ column from the AAO Newsletter. We anticipate it being replaced by regular 2dF science articles! Further hardware changes will be minor; for the latest information please refer to the 2dF Web Pages: http://www.aao.gov.au/2df/

In 98A there will be about 48 science nights devoted to 2dF – a 30% increase on 97B. 2dF will hog the dark lunations, and we expect it to continue to do so for the foreseeable future. Except for 1 night runs allocated to PATT proposals, programs will no longer be carried out in service. PIs for 2dF programs are therefore required to send at least one, and not more than two, observers for their 2dF runs. PIs should inform the AAO through the usual travel channels of the proposed observers well in advance of their runs.

The first 98A run is in late April; this gives a long period of downtime in February and March to work on remaining technical issues.

Hardware Status

Positioner

At the end of 1997, after various technical improvements, the positioner is running at 13 seconds/fibre. This figure is for going from one 400 fibre configuration to another, i.e. is an average over a typical 400 moves and 170 parks (parks are faster), or about 2.1 hours/field. There will be time to work on improvements before the April 1998 run and so this figure ought to come down. We anticipate we can eventually get down to 6–7 seconds/fibre (which has already been demonstrated for individual fibres) and thus to about 1 hour/field. While a factor of two seems a long way to go, one should note that in January of 1997 the figure was 36 seconds/fibre!

Reliability has also improved dramatically in 1997B. In some respects this is more important than raw speed for observing many fields in a night, as recovery from an error may involve an interruption to observing. By December we had achieved a very low error rate of 0.1% – however we do have *lots* of fibres so this means we can still expect an error in every 2–3 setups. More mechanical and software tuning remains to be done to reduce this rate and make it easier to recover safely and gracefully.

Local positioning accuracy remains at 20 μm, equivalent to 0.3". However global astrometric accuracy can still be problematic. The astrometric model over a 2° field plate takes account of off-axis field rotation and atmospheric refraction and is very sensitive – fields must be observed close to the hour angle they are set up for and preferably within ± 2.5 hours of the zenith. And one must use a set-up file for the appropriate declination. There may be remaining problems with the model, particularly at the edge of the field, which are subject to continuing investigation. Many of these problems will be eased considerably once we have mechanical field plate rotation, as rotation is the dominant effect. This is due to be installed some time in 1998, along with the 2dF Fibre Autoguider to handle the associated telescope juggling.

Spectrographs

We now have two spectrographs under full software control. These now have aluminised collimator mirrors, and tests on standard stars indicate we have a 20–30% better blue response than in January 1997, though this remains to be confirmed definitively. Some problems were experienced with holes in the back-illumination shielding in October and December, however these were fixed during the run. We now normally find this mechanism to be reliable and the effect of back-illumination (which is now reduced by time-slicing) to be immeasurably small in a 30 minute dark exposure. Pretty good, given that we have a 15W light source inside our spectrograph!

During December, when there were lots of high-resolution observations, we experienced temperamental problems from the grating angle drive. This was probably an electrical noise problem and will be fixed. We also find that some of the gratings do not seat correctly and must be tediously adjusted to get all 200 fibres on to the CCD (this is quite a tight fit!). A permanent fix for this is being developed. However, even with none of these problems observers should routinely allow 30 minutes for a grating change during the night, as access to the gratings on the 2dF Top-End Ring is complicated.

Order sorting filters for high-resolution work have arrived, the filter wheel hardware and software is currently being worked on, and it is expected these will be available for 98A.

Cameras

Camera#1 has a science-grade TEK 1024x1024 CCD, with good focus over the entire surface and no bad columns.

Camera#2 still has an engineering-grade TEK inside; this is due to be replaced by a science-grade chip between 97B and 98A. Both cameras will then have similar focus. This will greatly simplify the data reduction pipeline, as stable fibre profiles will be obtainable.

Focusing of both cameras is now considerably easier due to the new motor mikes and full software control from the observing system. Both cameras experience occasional halation problems; they need to be monitored and warmed up and pumped occasionally to keep this under control. The CCD system on the VAX still seems to crash occasionally when running with two CCDs; the cause of this problem is still being investigated.

Software Status

Field configuration – ‘configure’

Many astronomers downloaded the ‘configure’ software from the 2dF web pages and used it to set up their own draft configurations during 1997B. They have found it reasonably easy (and even fun?) to use.

Of course many bugs, problems and inadequacies in the manual were found, as was fully expected. Between 97B and 98A we will attempt to rectify some of these bugs, make improvements to the software and release a new version, this time for Solaris *and* Alpha systems.

Note: 2dF configurations set up this way must always be considered ‘draft’, as the exact astrometry model is determined at the start of a run; because of the tightness of the fibre packing small changes in the model can induce collisions. Also, fibres may be marked disabled during the run. When we acquire field plate rotation this constraint may ease, though should always be borne in mind. A recipe for dealing with this, while still retaining a high degree of completeness, is being developed by the galaxy survey team and may be incorporated in ‘configure’.

Observing System – ‘tdfct’

The control task ‘tdfct’ has been extensively debugged and rendered fault tolerant during 1997. It has also been fully ported to Solaris.

We now have full reliable Graphical User Interface control of the positioner, the tumbler, ADC, Spectrographs and CCDs.

The major main remaining issue that needs to be addressed is control of the telescope – it usually works, but the communication over the interprocessor link is still prone to random failure. Fixing this needs a new version of the TEL task on the VAX, which is due to be commissioned in February.

The much sought headers containing the fibre assignment information are now transferred automatically into the data files, despite some teething problems in 1997B!

Data reduction system – ‘2dFDR’

The data reduction system has proved reasonably easy-to-use and popular for online and offline data reduction. It has been continually developed by Jeremy Bailey through 1997 in response to user feedback. It now uses all the header information provided in the CCD data. You *can* simply reduce all your data by simply pressing REDUCE in the Graphical User Interface. However, it is still advisable to make simple sanity checks (tramlines, wavelength scale, etc. OK) on the results! 2dFDR is available from the 2dF web pages for Solaris, and soon for Alpha systems.

Remaining issues to be addressed include:

(a) Spectrum extraction: Tramlines are automatically computed – their shapes are computed from a spectrograph ray-trace model, which is accurate to half a pixel, and then tweaked up by a polynomial fit to a high S/N flat field calibration frame. The resulting map is then applied to subsequent data frames, with a small global shift and rotation allowed for to handle spectrograph flexure (typically ± 1–2 pixels over hour angles ± 3 hours). We are still using a simple box (i.e. unweighted) spectral extraction, though this is close to

optimal for fibre data where both the object and sky follow the fibre profile. However a profile-based algorithm *is* necessary to allow for fibre cross-talk and a global scattered light background (albeit small). Now we have a good focus on camera#1 we are investigating better optimal algorithms which will follow the empirical fibre profile variation across the chip.

(b) Throughput calibration: This is critical for sky-subtraction. We find that the throughputs for individual fibres vary by 10% after re-configuration i.e. a throughput map must be established for each setup as in other fibre systems. The good news is that the throughput is pretty stable with telescope position – it varies by <0.5% as the telescope is waved around the sky. We are also investigating non-greyness of the fibres – i.e. possible spectral variations at the few percent level. Currently we establish the throughput using a median of offset dark skies which represent a 10–15 minute overhead on each field. Twilight skies are not flat enough – they vary by a few percent on the huge scale of two degrees! We may be able to acquire a more stable tungsten lamp to illuminate the flaps so that we can use this as a reference once we calibrate the spatial illumination against the dark sky.

(c) Sky-subtraction: We currently subtract a median of the throughput normalised sky-fibres. However there are strong natural sky variations over the scale of two degrees in the ratios of the OH emission lines longwards of 6800 Å. If sky-subtraction in this region is extremely critical, enough sky fibres must be used so that many are available spatially near each object and 2dFDR will need to have an option to handle this. We are still investigating the best algorithms for this, issues of wavelength calibration and extraction feed back into this as well as the throughput.

(d) Wavelength calibration: 2dFDR automatically fits arc lines and interpolates the spectra to a common scale. We plan to build in more information about the accuracy of this process, to assist in projects aiming for highly accurate velocities.

(e) Combining of reduced runs: Currently 2dFDR provides a median option, which is not ideal but removes cosmic rays. (These can also be clipped by the profile extraction, but we need more accurate profiles first). A better approach will be to identify CRs and reject them (e.g. the IRAF crreject algorithm), though a naive application of this will misbehave due to spectral variations between consecutive exposures. These vary at the 10–20% level due to tracking and ADC effects. Again this will probably improve once we have mechanical plate rotation.

Despite this long wish list, it is clear that 2dF is producing better quality reduced data than any previous fibre system!

DATA WRITING PROCEDURES AT AAT

Chris Tinney

As of September 1997, the AAO is no longer able to prepare data tapes for observers. It is therefore extremely important that visiting astronomers prepare data tapes before they leave the mountain.

This change in our previous operating procedure has been prompted by the shortage of available staff at the telescope, together with the fact that we were finding the majority of visiting astronomers are now making their own data tapes anyway.

This change only affects the writing of data tapes at the end of an observing run. The AAO will continue to service requests for data to be extracted from the AAT archive.

In order to help astronomers “find” their data, a “cheat sheet” has been prepared and is available on-line as part of the AAO CCD Imaging Manual. It can be accessed at http://www.aao.gov.au/local/www/cgt/obsguide/appc.html/.

THE AAO/UKST H-ALPHA SURVEY: A rich new vein of resolved, old Planetary Nebulae

Quentin Parker, Malcolm Hartley (AAO), S. Phillipps (Bristol)

The new AAO/UKST Hα survey of the southern Galactic Plane and Magellanic clouds is now well underway, and is already living up to its promise to provide an unprecedented survey of ionised gas in terms of its combination of resolution, area coverage and sensitivity. Here we report on the first major discoveries with the survey material; namely, as a rich new source of evolved, extended, galactic Planetary Nebulae (PNe), based on simple visual scans of some of the first 3-hour survey exposures.

These new PNe are mostly invisible or occasionally barely detectable on previous deep, standard UKST R or J-band exposures of the field but are easily found on the new Hα exposures. So far, careful visual follow-up searches of 17 new 3 hour Hα exposures by Q. Parker and M. Hartley have revealed about 75 new, excellent PNe candidates, as well as the recovery of many known PNe. None of the new candidates can be found in the existing Acker 1992, 1996 PNe catalogues or from cross checking with SIMBAD on-line.

If this discovery rate is replicated throughout the survey, then about 900 new optically detected, resolved and old PNe could be discovered! This can be compared with the 1500 currently known or probable PNe of all types in the galaxy (both hemispheres).

The careful visual scanning of each Hα survey film by two experienced UKST staff (QAP/MH), though admittedly somewhat subjective, is a very effective discovery tool. In our opinion, the tenuous and varied morphological structure of these new low surface brightness, extended PNe would make their automatic detection by existing SuperCOSMOS image analysis software applied to the digitised films highly unlikely. They are not like galaxy or stellar images, and are found in very crowded regions. A duplicated visual search is a reasonable strategy to adopt at this stage.

These low surface brightness, extended PNe have proved elusive to many previous photographic or objective-prism searches. However, they are in themselves very interesting as they are more evolved and are dissipating into the ambient ISM. The progenitor stars have also faded. Indeed, most of the existing catalogued PNe are more point-source like in nature so we are tapping in to a significant rich new vein of evolved, extended objects. Due to their anticipated sheer numbers, the importance of this new source of PNe for studies of stellar evolution, PNe morphology, interaction and dissipation with the ISM and for galactic kinematics cannot be overstated.

Follow-up spectroscopy and associated narrow band imaging in other PNe emission lines is planned to confirm and explore the nature of many of these new PNe as well as the host stars which are expected to be approaching the white dwarf phase of stellar evolution.

Recent SuperCOSMOS scans of a selection of three of the scanned Hα fields will undoubtedly pick up many more unresolved or barely resolved PNe candidates for further study via comparison with the equivalent ‘continuum’ short-red exposures which have similar (slightly shallower) depth. Preliminary results will be presented in a forthcoming article.

Some of our brightest new PNe candidates have already been confirmed by careful checking with the equivalent deep R-band exposures where traces of the new PNe can just be discerned.

The back cover gives examples of four new PNe discovered by QAP from some of the early UKST 3-hour Hα exposures taken on standard 5° field centres (we have now adopted a conservative 4° separation for field centres for the survey proper). Each image is 2.6 x 2.6' in size.

Further updates will be placed on the associated www pages on a regular basis at: http://www.aao.gov.au/local/www/qap/halpha_discoveries.html. More general details concerning the Hα survey can also be found at: http://www.aao.gov.au/local/www/qap/halpha_pages.html.

Finally, please note that the black & white images shown here come from a flatbed scanner of polaroids taken from the survey films and do not reflect the excellent image quality of the original UKST Hα films.

AAO FIBRE OPTICS INSTRUMENTATION SHOWCASED IN TENERIFE

Fred Watson

Although optical fibres were beginning to make an impact on astronomy by the early 1980s, it was not until 1988 that a conference devoted exclusively to their use in astronomical instrumentation was held. ‘Fiber Optics in Astronomy’ took place in Tucson during a glorious week in April and, despite the rapid rate at which the technique was maturing, it still had about it a pioneering spirit, a ‘we-can-do-anything-with-this-new-technology’ optimism. By the time ‘Fibre Optics in Astronomy II’ came to Sydney in November 1991, real consolidation of the technique was under way. Progress reports on existing instruments jostled for space with descriptions of major new facilities—including something called 2dF...

Now, after a break of six years, ‘Fiber Optics in Astronomy III’ has been held. Hosted by the Instituto De Astrofisica De Canarias in Tenerife, its Scientific Organising Committee was co-chaired by Santiago Arribas and Evencio Mediavilla (both of IAC) and Fred Watson. The conference attracted 62 participants and, for the northern-hemisphere delegates at least, the Canary Islands in early December provided a welcome winter break. The IAC is well-used to handling meetings of this kind, and the practised hand of the Local Organising Committee was evident.

Once again, the spirit of the conference was one of consolidation, rather than revolution. This time, however, the major new facilities centred around 8-m class telescopes rather than those of 4-m, a reflection of the speed with which the larger telescopes have become benchmark instruments. Nonetheless, with fibre optics still offering one of the best ways of turning small telescopes into giants, many other worthwhile projects on lesser instruments were represented.

As with the previous meetings, the emphasis was very much on instrumentation and instrumental techniques, despite the Scientific Organising Committee's explicit request for papers presenting astronomical results when contributions were invited. Although there were, indeed, more science papers than at the earlier conferences, it is clear that astronomers would rather present their results in a topic-based forum than in one devoted to an observational technique—an entirely understandable view.

'Fiber Optics in Astronomy III' was divided into six sessions, broadly representing the functional areas in which fibres are used in astronomy. They were:

I: New advances in fibre technology and fibre testing; II: Multi-object spectroscopy; III: Two-dimensional fibre spectroscopy; IV: Projects for large telescopes; V: Multi-object and 2D infrared fibre spectroscopy; VI: Other applications.

Papers by AAO-based authors, or on AAO-related topics, were presented in all but the last session. Naturally, there was much interest in 2dF, and Ian Lewis gave a detailed review of its current status and first year of science. Both the previous meetings had had a touch of FLAIR about them, and that tradition was maintained in Quentin Parker's description of the 6dF proposal. A paper on SPIRAL's first-light performance was given by Matt Kenworthy of IoA, Cambridge, with co-authors Ian Parry and Keith Taylor, while Keith himself gave a masterly account of AUSTRALIS on behalf of the AAO/ANU/UNSW consortium. Finally, fibre sky-subtraction was revisited by Fred Watson representing a number of other AAO authors.

While several groups throughout the world now have considerable expertise in fibre-optics instrumentation, it is clear that AAO can still hold its head high in the field—even without the guiding hand of its former fibre specialist, Peter Gray! Unfortunately, Peter was unable to attend the Tenerife meeting, as was fellow fibre-optics pioneer, John Hill, who built the very first multi-fibre spectroscopy system. Nevertheless, there were several familiar faces from the early years of fibres work, and it was good to see them again. Newcomers to the field were also much in evidence, many presenting new and innovative ideas. It is thanks to all that 'Fiber Optics in Astronomy III' turned out to be a worthwhile and successful meeting.

THE OWLS AND THE PUSSYCAT

Sandra Ricketts

Those interested in the fate of the tawny frogmouth babies will be pleased to know that the first baby owl, when able to fly, was successfully reunited with its parents, and in fact all three of the babies grew to maturity.

All five birds were seen in various trees around the site from time to time at the end of last year, and it is assumed that they have all moved off to various hunting grounds.

However we hope that perhaps there will be a new family next spring.

EPPING NEWS

Helen Woods

Since the last Newsletter, David Lee has joined the AAO from Durham University to work on the AUSTRALIS Phase A study. Anthony Dunk is our newest arrival, and first for the New Year. He has joined us from Toshiba International as a software engineer, and will be here for a period of two years to work on IRIS 2.

Congratulations to Russell Cannon who has been awarded the title of Adjunct Professor in the Faculty of Science at the University of Sydney. The award has been made in recognition of Russell's contribution to the School of Physics, regarding the observational aspects relating to the AAT in general and the two-degree-field in particular. Russell hopes to use the appointment to develop closer research links between the AAO and Sydney University.

LETTER FROM COONABARABRAN

Rhonda Martin

It's raining again. Mind you, it is very welcome as since the last Newsletter it has become dry and John's sheep had to give up their snorkels and dig out the suntan lotion. Merinos with burnt noses are not pretty. (Mind you, they are not very pretty at the best of times!)

Of course, the great thing that happened this quarter, apart from the usual superb work done at this telescope, was the Great Pilliga Fire which brought excited telephone calls from all over the globe from observers wondering whether we were still here or had been burnt out. Perhaps the fact that the telephones were answered should have told them something, but we were touched by their concern.

I missed all the excitement, being on leave at the time, but the photographs taken from the AAT catwalk were awe-inspiring, particularly one panoramic shot which showed just how huge this fire was that burnt out over 160,000 ha of bush. Several of the observatory staff were seen on the local and national news cooking bacon (mmmm? Gordon?) and generally being very helpful. It was wonderful to see just how the town pulled together to make sure that firefighters from all over the state, and from Queensland, were looked after, fed, accommodated and made to feel welcome.

Open Day was held in October to smaller crowds than usual, but many people came from the city especially for the occasion and it is always a pleasure to show off the Observatory to people like this who are so interested in what we are doing. This year the local Astronomical Society had a display of members' telescopes, both commercial and home-made, and these aroused quite a bit of interest, along with young sticky fingers lingering lovingly on eyepieces, but it was fun.

We are pleased that Kevin Cooper has come through two operations successfully and is looking hale and hearty. We wish him well.

BOARD NEWS

Roger Bell

1997 Bok lecture*:* The Seventh Annual Bok Lecture was held at Coonabarabran on 27 October and at Dubbo on the 28 October. This year, Dr Rachel Webster from the University of Melbourne gave the lecture 'Gravitational Lensing – Using distortions to map the universe.'

Forty people in Coonabarabran and 65 people in Dubbo were inspired by Dr Webster's entertaining and well-illustrated talk which used a specially-made perspex lens to demonstrate gravitational lensing.

The Bok lecture was established in 1991 to let the local community know about the work of astronomers at Siding Spring, and to remind them of the importance of keeping the skies dark.

Board changes: The Anglo-Australian Telescope Board has undergone some changes recently. Ron Ekers replaced Lawrence Cram in July 1997. Max Brennan's term expired at the end of December 1997 and his replacement has not been announced. Roger Davies is now Chair and Jeremy Mould is now Deputy Chair.

Changes to the Schmidt Telescope Panel (STP) and the Advisory Committee for Instrumentation on the AAO (ACIAAT): John Norris's (MSSSO) term on the STP expired at the end of 1997, and Chris Collins's (Liverpool JM) term will expire at the end of April 1998. Mike Bessell (MSSSO) and Jon Davies (Cardiff) will replace them. Tom Shanks's (Durham) and Peter McGregor's (NSW) ACIAAT terms expired on 31 December 1997. Steve Phillipps (Bristol) and Matthew Colless (MSSSO) replaced them on 1 January 1998.

The AAT Board thanks John, Chris, Tom and Peter for their contributions to these two important committees.

Anglo-Australian Observatory–Australia Telescope National Facility 1998 Joint Symposium: The AAO–ATNF Joint Symposium will be hosted by MSO in Canberra on Wednesday and Thursday 18–19 March 1998. Contacts are Baerbel Koribalski for the ATNF, Peter Wood for MSO and Chris Tinney for the AAO.

BUSHFIRES AT COONABARABRAN

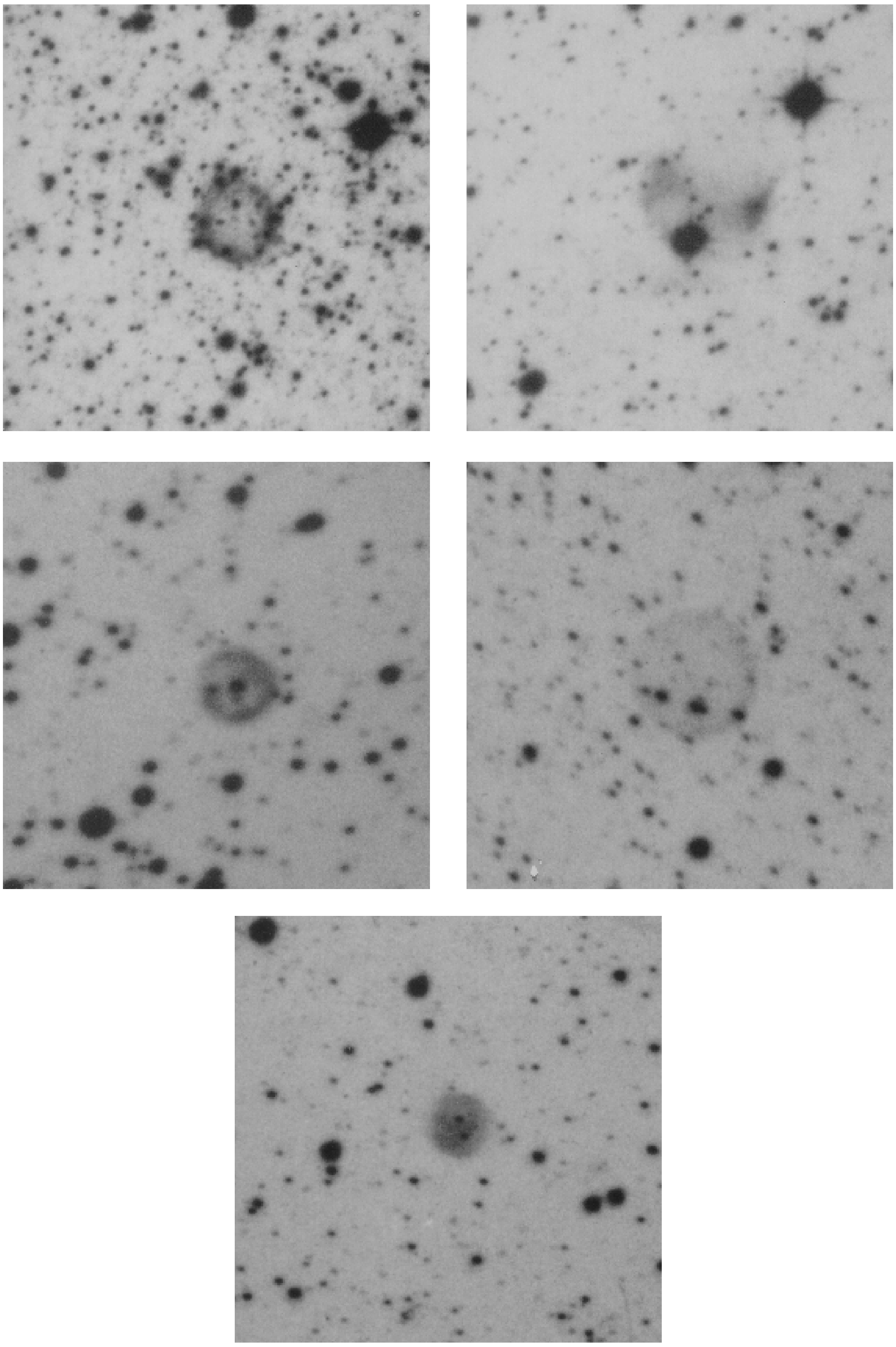
Bill Green, Bob Dean & Roger Bell

The recent bushfires in the Pilliga forest near Coonabarabran were called the most destructive ever, and 143 500 hectares of forest were destroyed. Fortunately the fires did not endanger the telescopes at Siding Spring Mountain. At the closest point they were 20 km away.

However, the Observatory played a major role in assisting, gathering and disseminating information. A number of staff members and their families were directly involved in the fire operations — at the fire front; catering and at the operations centre. As well, the Anglo-Australian Observatory provided important communication links via its Internet connections. This enabled people in the operations centre to access real-time meteorological information and the Rural Bushfire Services network of computers. And because of its vantage point, staff were able to report any new outbreaks. For many years, there has been a fire team at the Observatory. There is a full-time captain and 12 volunteers made up of both Australian National University and Anglo-Australian Observatory staff. They have been trained to cope with bush and building fires. They are also trained in first aid and rescue work. The team has a fire tender which is well equipped and carries 2000 L of water.

A system of pressurised hydrants was installed when the Observatory was set up and there are hoses available to defend the area if a bush fire occurs. The hydrants are fed from an electric pump, and there is a standby diesel engine in case of power failure. Tanks on the mountain hold 900 000 L of water.

You can see Chris McCowage's images of the fire at the Anglo-Australian Observatory's homepage, http://www.aao.gov.au.



New planetary nebulae discovered in the UKST Hα survey. Each image is 2.6 x 2.6' in size. Top left & top right are both from exposure HA17614 (field 334). Middle left is from exposure HA17617 (field 226) & middle right from exposure HA17619 (field 392). The bottom image gives a further new PNe discovery taken on one of the new 4° field centres (exposure HA17702, field 1063H 19h12m, –12° B1950). See page 13 for details.

editor HELEN JOHNSTON editorial assistant SANDRA RICKETTS

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PO Box 296 Epping, NSW 2121 Australia

Epping Lab
Telephone +61 2 9372 4800 Fax +61 2 9372 4880 email < *user*@aaoepp.aao.gov.au >

AAT/Schmidt
Telephone +61 2 6842 6291 Fax +61 2 6884 2298 email < *user*@aaocbn.aao.gov.au >

URL < http://www.aao.gov.au >