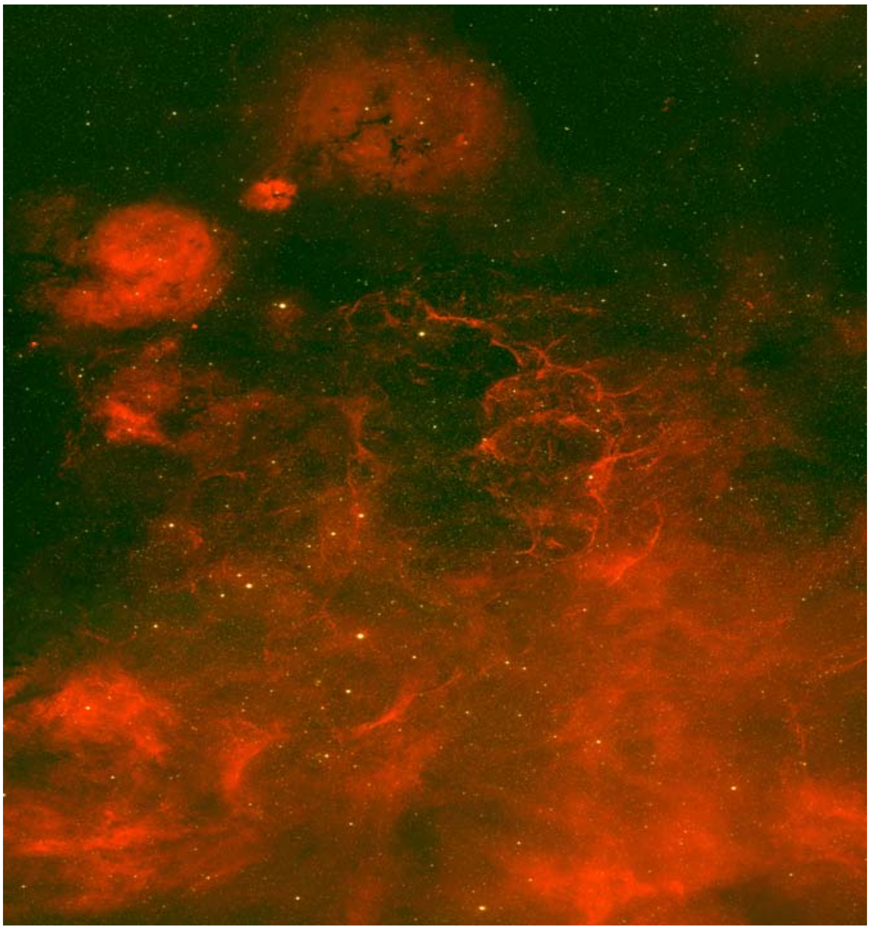
NUMBER 100 JULY 2002

AAO NEWSLETTER

ANGLO-AUSTRALIAN OBSERVATORY

100 not out!



It is our 100th issue, and we celebrate with lots of colour, a revisit to gems from old issues, and another poster for you to keep. Our articles mark the completion of landmark projects like 2dFGRS, the H-alpha survey and the delivery of OzPoz; and the start of new challenges like AAΩ and the Dome Airconditioning Project. This mosaic, constructed by Mike Read (WFAU) and further modified by Quentin Parker (AAO/Macquarie), is centred on the Vela Supernova Remnant. It was taken as part of the H-alpha Survey, and emphasises the survey's great detail.

contents

DIRECTOR'S MESSAGE

Almost 30 years into its existence, the AAO celebrates another milestone; the 100th AAO newsletter. This landmark provides an opportunity not only to reflect on past achievements, but to consider how to build on these successes for the future.

As attested by the feature article in this Newsletter, the 2dF Galaxy Redshift Survey, completed in April, is one of the highest impact science programs ever carried out with the AAO telescopes. AAO staff have played a key role in facilitating this survey, from taking the initial UK Schmidt photographic material on which the input catalogue was based, to the building and operating of the 2dF instrument which obtained over 225000 spectra for the survey. AAO staff can take tremendous pride and satisfaction on the outstanding results being obtained from this survey by the 2dFGRS team. However, the AAO can not afford to rest on its laurels. Even as the 2dF survey analysis is being done and the papers are being written, the AAO must look to the future. With the galaxy redshift survey now complete, there are new opportunities for survey programs on the AAT. These are likely to be based on the new generation of digital imaging sky surveys (SDSS, INT WFC) that are beginning to appear, and there is ample opportunity for AAT users to capitalise on 2dF's uniqueness in exploiting these new data-sets.

In some respects, the UK Schmidt has shown the way for the AAT. With the major photographic surveys now drawing to a close (see the article by Quentin Parker), the Schmidt has embarked on the 6dF galaxy survey; a new spectroscopic program based on the recently available infrared 2MASS data-set. Now a year into operations, the 6dF galaxy survey has already amassed over 25000 spectra and the survey team is preparing an 'Early Data Release' in September. The success of the 6dF survey is also attracting many new users to the telescope. Moreover, additional resources provided by new users have enabled the Schmidt to extend its operation into bright-of-moon time — currently the UK Schmidt is observing more nights per lunation than at any other time in its history.

Both 2dF and 6dF are prime examples of AAO's success in instrumentation, a success the AAO continues to build on with instruments such as OzPoz (see the article by Peter Gillingham) and IRIS2. A hallmark of AAO success has been innovation, well illustrated by the development of Tunable filter imaging (see the contribution by Joss Bland-Hawthorn and Lucyna Kedziora-Chudczer) and the new AAΩ program (reported on by Terry Bridges) which builds on the pioneering work carried out on sky cancellation techniques (nod-and-shuffle) and new Volume Phase Holographic Technology.

The innovation does not stop there. There are also plans for the AAO to investigate a fibre-positioning system comprising over 4000 fibres, based on the Echidna concept, as part of a potential 2nd generation Gemini instrument — for surveys of the high redshift Universe and our own Milky Way Galaxy halo. A prototype instrument (currently dubbed Schmechidna) could be built for use on the UK Schmidt. This would provide the UK Schmidt with the capability to observe over 20000 objects per night, facilitating a new generation of stellar radial velocity surveys.

By 2010, perhaps the AAO newsletter will be celebrating its 125th issue with a special feature on the z=3 million-galaxy survey carried out with a super-Echidna based fibre system on Gemini or the 10 millionth stellar radial velocity obtained with Schmechinda on the UK Schmidt.

Brian Boyle

This Issue: Scattered throughout this, the 100th Issue, you'll find gems from previous issues, collated by the Editors, Ray Stathakis and Sandra Ricketts. Two authors dominate — John Storey, now at UNSW, and David Allen. We salute their wit which leavened the reams of instrumentation reports. Was it something about working in the infrared? Picture credits: p6 Cartoon by Dave Allen; p25 Cartoons by Jonathan Pogson; p32, 33 Photos by the OzPoz team; Many thanks to Paul Bourke of Swinburne Centre for Astrophysics and Supercomputing for the centrefold graphics.

Next Issue: Articles 2 – 4 pages, deadline October 1, 2002. Smaller articles, deadline October 21. Email newsletter@aaoepp.aao.gov.au for submission details.

ATAC CORNER

Brian Schmidt (Chair of ATAC), Michael Drinkwater, Duncan Forbes, Paul Francis, Brad Gibson, Elaine Sadler, Chris Tinney

To keep the community up to date, the Australian Time Assignment Committee (ATAC), has decided to include information in each newsletter to help the community better use its telescope resources.

UK Schmidt Time Allocation Procedure Change

ATAC has recommended to the director that it now review the UK Schmidt Telescope proposals as part of its normal Time Allocation procedure, rather than these proposals being evaluated by a special committee. Instead of using the existing 6dF application form, ATAC applicants will now choose 6dF as one of their instruments on the standard ATAC application form, and fill out the Instrument Request Form as appropriate. We hope that this will allow users to better integrate 2dF and 6dF proposals, and the time allocation committee to appropriately weight the merits of proposals that need time on any combination of instruments.

Service Observing

Each semester, ATAC, in cooperation with its UK equivalent, PATT, allocates time for service observing. A panel of three astronomers (one ATAC, one PATT, and one AAO) review these proposals (which may ask for up to 3 hours observing time), and proposals that are judged to be of equivalent scientific merit per observing time to normal proposals are graded and placed in a queue for service observing. Following advice from the AAO Director, ATAC and PATT jointly set aside only enough nights for service observing so as to maintain a level of over-subscription which is comparable to that for standard AAT proposals. This means that in any given semester, certain instruments for which there is currently insufficient demand to warrant having a full night allocated will not be scheduled for service time. All service proposals expire 12 months after submission, but may be re-submitted. For Semester 2002B, 2 nights of observing on the RGO spectrograph, and 2 nights of observing on IRIS2 were allocated by ATAC. All other instruments had less than 1 night of demand.

2002B Proposals

A total of 44 AAT proposals and 18 Gemini proposals were assessed by ATAC this May, with a healthy oversubscription for time (bright = 3.9, grey = 3.1, dark = 2.7). There was an unusually large overseas demand this semester for the AAT (46% of time had a foreign PI), and ATAC continued its policy of judging purely on the perceived scientific merit of each proposal. For each proposal, at the time of grading, we attempted to provide comments that reflected why a proposal did or did not get time. In general, proposals that did not fare well tended not to put the proposed research into the larger picture of Astronomical research, making it difficult for non-specialists to judge the work as interesting. We encourage proposers who are frustrated by the allocation process to discuss their concerns with members of the TAC, or even ask for advice from members of the TAC on how to make their proposal more competitive.

THE DAVID ALLEN PRIZE — CALL FOR NOMINATIONS

Helen Sim

The Astronomical Society of Australia awards an annual prize for communicating astronomy to Australians. It commemorates the life and work of David Allen, one of the most innovative and productive astronomers of his generation, who died of a brain tumour in 1994. David was a great communicator. He had a sharp and ready wit, and an easy way with words, as evidenced by several pieces of work reproduced in this issue.

The prize — $1000 and an inscribed plaque — is given for a body of work that is:

- in any medium that is widely accessible to Australians
- includes (but is not necessarily limited to) work published, broadcast or performed in the 12 months prior to the close of nominations
- uses language appropriate for the general public
- retains the integrity of the science.

Residents of Australia and Australian citizens (including ex-patriates) are eligible. Both individuals and groups may be nominated. A winner of the prize may not be nominated again until the fifth year after he/she has won.

Self-nominations are accepted. Nominators must initially supply: up to two pages of supporting material, containing specific references to the items on which the nomination is based; the names of two or three referees familiar with the nominee's work; and from the nominee, written acceptance of the nomination. The closing date for the nominations is **Friday 23 August**. Nominations should be sent to Helen Sim at Helen.Sim@csiro.au. For more information see: http://www.atnf.csiro.au/asa_www/DAP/

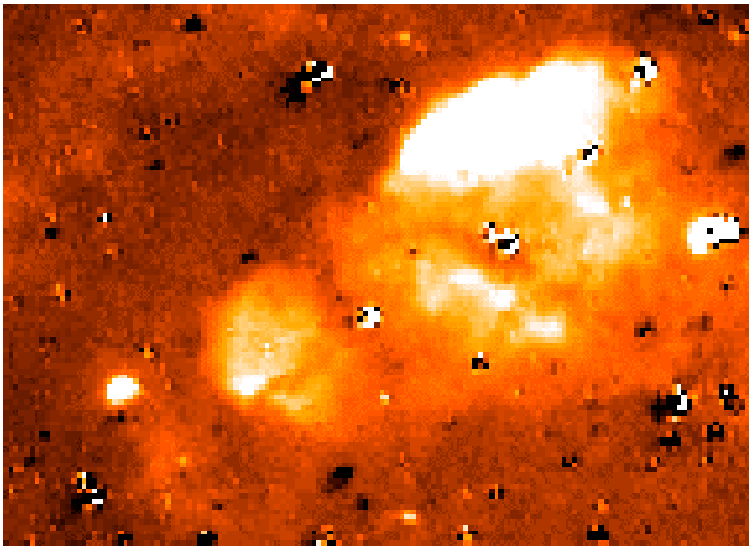
The winner of the 2002 David Allen Prize will be announced and presented in November this year. In 2003, nominations will be called for in February, and the award presented in July.

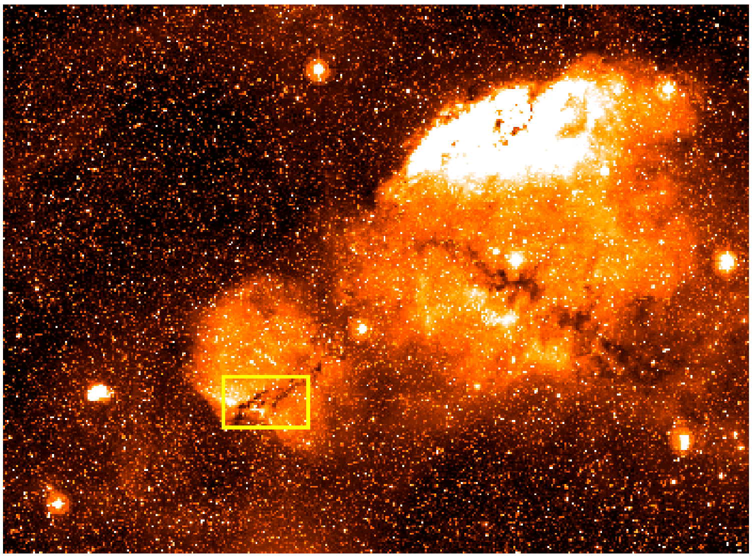
THE AAO/UKST H-ALPHA SURVEY DRAWS TO A CLOSE AND WITH IT SURVEY PHOTOGRAPHY AT THE UKST PASSES INTO HISTORY.

Quentin Parker (Macquarie University / AAO)

After five years the AAO/UKST H-alpha survey is drawing to a close. This marks the effective end of survey photography at the UKST. This final great photographic survey represents the culmination of more than 25 years of outstanding service to wide-field sky surveys. It is no exaggeration to say that our view of the universe has been significantly changed through this panoramic eye-on-the-sky! It is perhaps fitting that a telescope that has excelled at innovation should finish its photographic survey mission with a product that has several notable firsts to its credit.

The H-alpha survey is the first large-scale narrow-band survey to be undertaken at the UKST. It uses the world's largest monolithic interference filter in astronomy to undertake the task. The detector is fine grained Kodak Tech-Pan film, again the first time such a large program has been done with a film-based emulsion, and one of such exceptional speed, uniformity and resolution. The survey products are being released to the community **solely** in digital form using SuperCOSMOS machine scans of the original films done at the Royal Observatory Edinburgh. Again this is a first for any photographic survey. As at 21/05/02 the survey is 91% complete to A-grade and now 100% complete to B-grade. A-grade completion to at least 95% is anticipated by the end of the year.

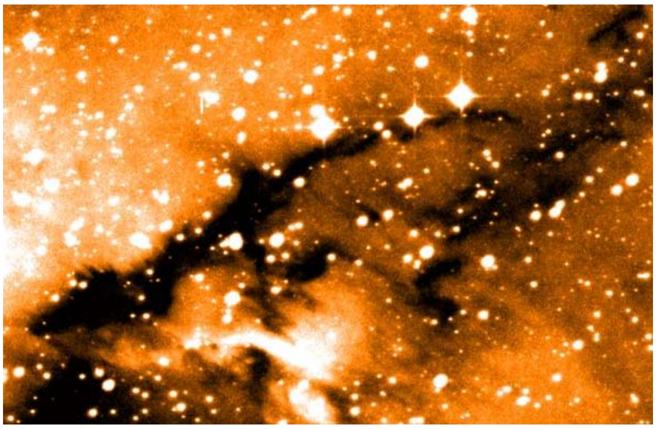




First H-alpha Survey Region Now Accessible On-line

The initial release of 54 H-alpha fields was put on-line and announced to the community during the U.K. National Astronomy Meeting in Bristol in April. Further regular releases will occur until the full survey is available, probably in early 2003. This mammoth task is being undertaken by the Wide Field Astronomy Unit of the Institute for Astronomy at the ROE. This close co-operation between the AAO and WFAU/ROE continues the historic linkage between both sites that has proved so beneficial in the past.

The comprehensive AAO/UKST H-alpha Survey web site http://www-wfau.roe.ac.uk/sss/halpha is available for more information. Pixel image data at full 10 μm resolution is available for both the H-alpha and matching SR (short-red broad band) exposures together with associated IAM (image analysis mode) parameterized data for detected point sources and discrete objects. The SHS (SuperCOSMOS H-alpha Survey) interface has the same look and feel as the current SuperCOSMOS SSS surveys on-line but with some additional extra functionality due to the special nature of the H-alpha survey, e.g. ability to specify regions in galactic as well as equatorial co-ordinates.



To indicate the level of detail available from the new H-alpha data the accompanying images (opposite) show an area from the recently released Southern H-alpha Survey of Gausted et al. (2001) undertaken at CTIO together with the equivalent area from the UKST H-alpha survey. The upper figure, which is 1.25 degrees in the vertical direction, is the full 48 arcmin resolution SHASSA data whilst the lower figure is 16x blocked data from the equivalent SuperCOSMOS scan of the same area. The inscribed rectangle indicates the region of SCOS data shown above, at full 10 µm resolution and only 6 arcmin in the vertical direction. The sharp-eyed amongst you may even spot a slow-moving asteroid visible as a short vertical line in this excerpt from the 3 hour exposure!

The tremendous increase in information content of the UKST survey due to the considerably higher spatial resolution is clear, though the SHASSA survey does have the benefit of being calibrated and covering the whole Southern sky.

Exploiting the Survey: Community Invitation

With the availability of on-line survey data the community is invited to consider its use when undertaking any investigation in the southern Galactic Plane. Many exciting discoveries have already been made resulting in several main-line journal publications and these should grow substantially with direct on-line survey access. A brief list of the most significant current projects exploiting the survey data is given in the panel at right.

The UKST and the dedicated team of astronomers, technicians and specialists that have passed under its watchful gaze have been witness to significant shifts in our understanding of the Cosmos, shifts in which the UKST has played no small part. It will thus come as no surprise that this final photographic survey should leave an equally impressive legacy. At this stage the new AAO/UKST H-alpha survey provides a survey of Galactic ionized gas that is unsurpassed in terms of its exceptional resolution, full southern Galactic Plane coverage and decent sensitivity. It will be some time before any equivalent survey will match it in terms of these combined properties.

And Finally…

The UKST has managed to re-invent its mission on several occasions, especially over the last 10 years, to remain scientifically relevant and effective in an era when all other major Schmidt photographic telescopes have fallen by the wayside. This reforming zeal continues to this day with the commissioning of the unique 6dF multi-object fibre spectroscopy facility, ensuring a productive, active and exciting time for UKST-based science for several years to come.

Acknowledgements

Grateful thanks must go to all those who have enabled this survey to succeed but particular thanks to Malcolm Hartley, Fred Watson, Ken Russell and Paul Cass at the UKST, and Harvey MacGillivray, Nigel Hambly, Sue Tritton and Mike Read at the WFAU, together with Steve Phillipps (survey co-PI) and Mike Masheder at Bristol.

The AATB, WFAP, PPARC and AAO are also thanked for their support.

Current H-alpha Survey Projects

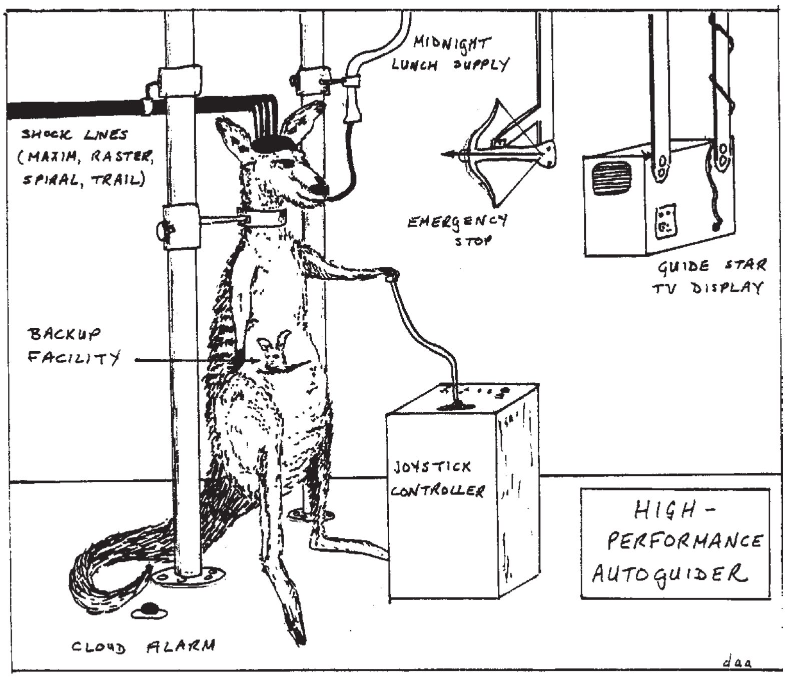
Searches for new Planetary Nebulae in the disc and bulge (Parker et al.) – perhaps one of the most exciting projects to come from the survey – more than 1000 new Galactic PN have already been discovered.
Studies of triggered star formation (Bristol & Wollongong groups)
New Galactic Plane supernova remnants (SNR project, Walker et al.)
Large scale Galactic Plane study (Phillipps, Parker – consortium project)
Search for Magellanic Cloud emission line objects (Morgan, Fillipovic et al.)
Herbig-Haro objects in star forming regions (Mader et al.)
Wolf-Rayet stars as CSPN discovered from the survey (Morgan & Parker)
Comparison studies with MSX imaging (Cohen et al.)
CO and H-alpha mapping of star forming regions (Masheder et al.)
HII region maps and comparison with the Marseille H-alpha survey (Russeil et al.)
MOST radio correlations with the H-alpha survey (Green et al.)
Emission line stars (Drew & Pozzo)

99 ISSUES OF NOSTALGIA

The cover stories of the AAO Newsletter reported many scientific milestones: the most distant objects – QSOs confirmed at the AAT held first and second place in 1985; the first detection of clouds on the dark side of Venus; the highest velocity absorption in a BAL QSO; first detection of helium lines in the 8–13 μm region; the discovery of shells around ellipitical galaxies. Major astronomical events which made first page included Halley's Comet (1986), Supernova 1987A and the collision of Comet Shoemaker-Levy with Jupiter in 1994.

The covers also marked technical firsts: the best spatial resolution of the Galactic Centre at 2.2 μm not once but twice (1982 & 1985); the highest spectral resolution for a QSO observation (*R*>15000) was obtained in 1978 on the RGO spectrograph; η Car was observed at the highest spectral resolution in the infrared in 1985. Technical breakthroughs included: speckle interferometry of binary 6 Ori in 1979, resulting in spatial resolution of 0.03"; the first AAT CCD image in 1981; Taurus cubes (also 1981); High Speed Mode observations of an eclipsing binary in 1983; and most poignantly, the first multi-object observations from the AAT in 1984.

LDSS enabled spectral observations of objects to B=23.5 in 1986; and early spectral resolution records were shattered by observations of SN 1987A using the "wooden" Coude spectrograph, with *R*>500,000, to be followed by the first UHRF spectra with *R*>900,000 in 1993. Many other instruments have been introduced, most recently IRIS2 in Issue 99. However, the proposed replacement for the RGO spectrograph autoguider (Issue 13, right) was never implemented (to my knowledge).

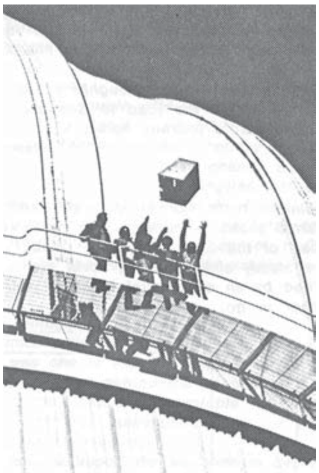


Some articles stand out: throwing the old RGO console off the catwalk (depicted opposite, Issue 35); the story of Percy, the ghost in the basement of the Massey building (Issue 29); and the detection of sparrows in IRPS data (Issue 22).

The Epping Column holds many familiar names — particularly notable are the number of students and research assistants who went on to become staff members or regular visitors: e.g. Nigel Douglas, Michelle Allen (now Storey), Nick Lomb, Peter Gray, Pat Roche, Matthew Colless, Richard Hook, Shaun Hughes, Joss Bland-Hawthorn, Helen Johnston, Chris Tinney, Jason Spyromilio, Vikki Meadows and Anna Moore.

Some quotable quotes:

- "those astronomers are a bit weird, but quite nice, really" (Epping Column, Issue 8)
- "Will I be able to observe tomorrow?" (Ron Buta after falling from the inside catwalk at the AAT)
- "The PDP8/I twice caught fire (filling the Control room with smoke) and also survived having its innards zapped by 110 volts AC under the guidance of an inquisitive astronomer" (article advertising the availability of the IDS for other observatories — amazingly the offer was taken up)
- "interested astronomers would probably do better to prevail upon friends visiting the AAT to squeeze in an extra integration or two" (did we really say that? From an article about a proto-service program in 1982)
- "Dave Hanes, having just finished a week's observing, had to drop out after only 21 km" (report on the 1982 City-to-Surf run — they made them tough in those days)
- "We have (if I may be conceited) the best telescope in the world" (Dave Allen on starting the



first tenured astronomer position — for a different opinion see Roger Griffin's article in Issue 24)

- "Bets are now being taken in Epping for which of these voluble astronomers will dominate the conversation when they finally meet face-to-face" (concerning the imminent arrival of a certain student called Joss Bland, and Dave Axon)
- "Suddenly a gap appeared in the clouds. A star appeared in the gap. The telescope slewed. Liquid nitrogen poured out of the dewer and into the Apple. The IRCCD saturated in all 128 pixels. The clouds regained control." (from John Storey's account in Issue 35 of the first AAT run of the UNSW IR CCD. For the young readers, an Apple was a primitive form of computer, similar to a slide rule.)
- "Honesty is the last resort of a desperate man, and it is in this vein that I wish to address the issue of the status of the 2dF project." (Keith Taylor, January 1995)

Ah, the memories!

POETRY CORNER

Over the years there have been a number of items of a poetical nature — a couple of samples follow, from the most prolific poets:

"The Two Micron Photon" by John Storey

Little photon, warm and soft
You've come to us from far aloft.
An HI atom was your Mamma
(She used to call you Brackett gamma).
But now a million years have passed –
How time flies when you go fast!

Your long wavelength made chances good
You'd make it through galactic mud.
Indeed you dodged the gas and dust;
Your motto was, "The Earth or bust!"
No way would silicates defeat you.
The way they did your friends in blue.

Your little heart was filled with fear
As you plunged into our atmosphere.
"Holy cow!" you cried out loud;
"It's Siding Spring - but where's the cloud?!"
At last your journey's end was here –
The AAT was looming near.

Boinng! Off the mirror! Up you go.
To secondary, then down below.
Yes, ATAC, with outstanding foresight,
Have I.R.P.S. on tonight.
(And certainly it was heroic
The way you bounced off the dichroic.)

You're glad the window's made of sapphire
(Glass really would have raised your ire.)
Indeed it's hard to keep from gloating:
Such luxury – an a.r. coating.
Through apertures, and then – oh, phew!
The CVF was set for you.

Your journey over – suicide
In indium antimonide.
But onwards does your soul continue.
Electrically – you had it in you.
Ignoble fate for such a martyr
To end up in the Interdata.

We missed you, too – where were we?
We'd slipped outside to have a ---.

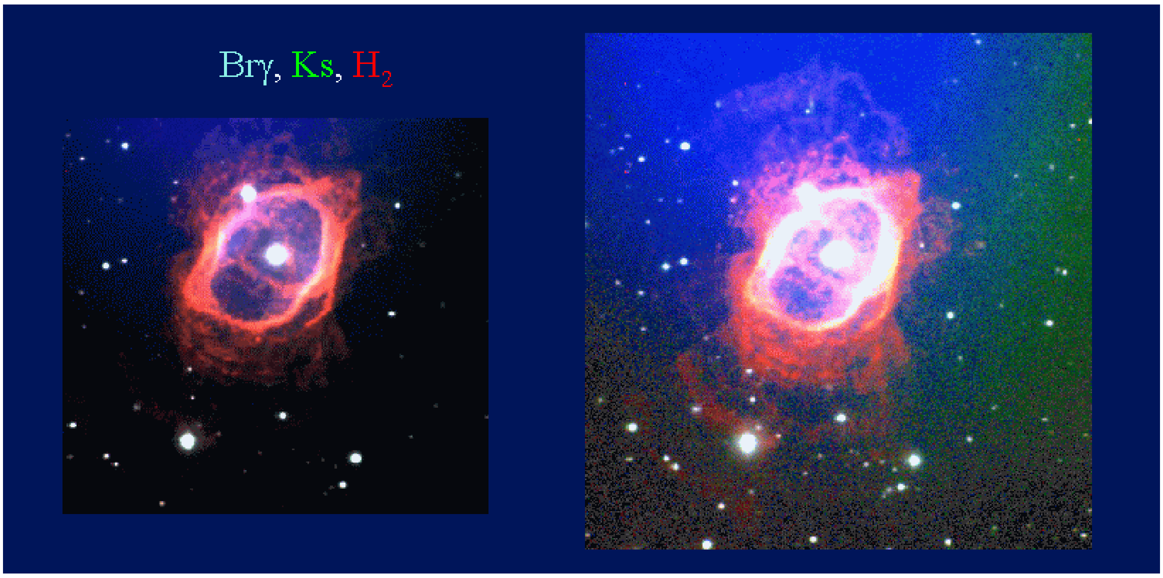
"z = 0" by David Allen

Can there be any star alive
To tell the tale of redshift five?
Does matter stretch for evermore
Or does it end at redshift four?
The brightest quasars I can see
Are numerous at redshift three
The BL Lacs are numbered few
Within the zoo at redshift two.
Whole galaxies have come and gone;
I see some yet at redshift one.
Such strange cosmology I'm taught
As I sit here at redshift nought.

Just a few new findings since 1983 render this poem somewhat out of date.

Not exactly poetry, but in Issue 28, his first as editor, David Allen issued a challenge to complete a limerick. The winner as announced in the following issue, was Pat Roche with the ditty:

Observers whose technique is lax
Will not be allowed on the VAX
They'll forfeit analysis
And get data paralysis
It's a clear-weather telescope tax.

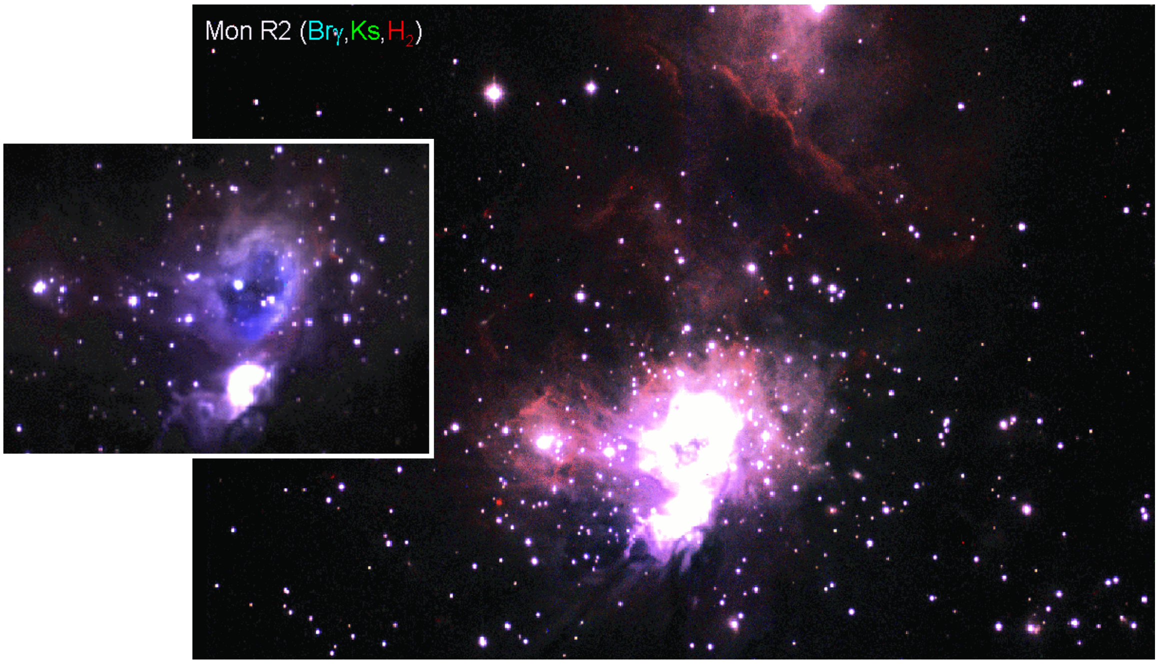


Results from IRIS2

By the time you read this, all modes in IRIS2 should be available to observers. Here we present images of two famous sky fields taken during the commissioning runs. These false colour images combine emission from Brγ, Ks continuum light, and H_2. Above we see the striking planetary nebula NGC 3132. The central star has ionised the interior gas, causing it to emit in Brγ, while the complex filamentary structure at the outer rim is formed of cooler gas, emitting in H_2. The two images are the same frame at different saturation levels — on the right we see faint biconal emission extending over the full field.

Below, Monoceros R2, a very young embedded star cluster and an associated Molecular Cloud, is shown in the same wavelength bands. Mon R2 is one of the closest star clusters still embedded in a molecular cloud. The inset shows the brightest region, believed to be a blister HII region, at a different saturation level.

(Object descriptions from the HST Heritage Project, the 2Mass Image Gallery and the JAC Image Gallery.)



2DF UPDATE

Terry Bridges for the 2dF Team

It's been a while since the last 2dF update, and there are several new features and improvements which have taken place in recent months.

We now routinely autoguide with 2dF, thanks to guider software written by Steve Lee. Not only does this make the Night Assistant's life easier, it also results in higher throughput.

Jeremy Bailey is continually updating the 2dF data reduction software (`2dfdr`). The most recent version of `2dfdr` (2.3, available for both Solaris and Linux Redhat 7.* systems) incorporates new fibre throughput calibration methods from Scott Croom. These new methods improve upon the existing "skylines" throughput calibration technique, by determining the fibre throughputs from the *total* flux in a number of sky lines, rather than comparing sky emission on a pixel-to-pixel basis. This has the advantage of correcting (to first order) for any variations in the spectral PSF across the 2dF CCDs, and has been shown to result in better 2dF sky subtraction.

In May 2002, we commissioned the first stage of plate rotation with 2dF. The hardware and software for doing this had been largely in place for several years, but had never been implemented. Chris McCowage and Garry Kitley got the hardware going, while Tony Farrell worked on the software. Plate rotation was then tested on the sky during the May 2dF run, and found to work very well. It is at the point now where it can be adjusted by the Night Assistant during field acquisition and subsequent exposures.

Further tests are planned for July, and the next stage will be to incorporate plate rotation with autoguiding, which will happen during the coming year. But even at this stage, plate rotation should make a significant improvement to 2dF throughput, especially for objects on the edge of the field where rotation corrections are the most important.

Hopefully by the time this Newsletter comes out, we will have a new version of `configure`, which can be used for 2dF, 6dF, and OzPoz. This new version will fix several bugs with the existing version of `configure`, as well as to add new functionality (e.g. the ability to specify *exactly* how many fibres you wish to place on sky, for each spectrograph separately).

As always, see the 2dF WWW page for the latest news about 2dF, and to get `2dfdr`, `configure`, and other software: www.aao.gov.au/2df.

PROGRESS IN THE FMOS-ECHIDNA PROJECT

Anna Moore

The Echidna spine drive system is planned to position as many as 400 optical fibres at the prime focus of Subaru, as part of the Faint Multi-Object Spectrograph (FMOS) project. The project has recently completed the preliminary design stage and is currently entering the initial stage of the final design. The preliminary design study for the fibre positioner finalised the designs of the Echidna spine and mount developed during the concept design stage. Twenty of these spines were assembled and incorporated into a single module. The module was accompanied by a simple, one dimensional, "FPI" for imaging of the spine fibres. Suitable electronics were designed and built along with software that controls the spine reconfiguration. This prototype instrument is located in the old "OzPoz" lab at the Epping site. In addition to the development of the Echidna positioner system, the prime focus corrector design was finalised and the blanks have been ordered.

A photo of 20 Echidna spines mounted in the prototype module.

Many congratulations go out to the FMOS-Echidna team for a successful PDR!

TAURUS TUNABLE FILTER – THE FIRST 5 YEARS

Joss Bland-Hawthorn & Lucyna Kedziora-Chudczer

The Taurus Tunable Filter (TTF) has now been in use at the AAT for five years, and for the first three years was also used at the WHT. During this period, it has been consistently allocated 10–15% of AAT telescope time, and has carried out an impressively wide range of scientific projects. The TTF provides wide-field (10 arcmin) narrowband imaging from 370 to 1000 nm with resolving powers ~ 100 to 1000. Charge shuffling is synchronised to bandswitching which greatly suppresses systematic errors. In addition, a time series mode is available which has led to important new work on compact variable sources. For more information on TTF see http://www.aao.gov.au/ttf.

Surveys of Star Forming Galaxies

Tunable filters are ideally suited to surveys of star forming galaxies in different environments as the object selection is based on the property we are trying to measure – the star formation rate (SFR) from the Hα line. For the TTF Field Galaxy Survey, Heath Jones observed four clusters and nine field positions in Hα and Hβ (Jones & Bland-Hawthorn 2001). The survey set out to derive Hα luminosity functions in three discrete wavelength intervals at z=0.08, 0.24 and 0.39 to investigate the predicted decline in SFR after z~1. One of the interesting surprises was a population of compact sources found to have moderate amounts of Hα emission, which would have been dismissed as stars in earlier surveys. In a new study, Tresse et al. (2002) combine the TTF Field Galaxy Survey measurements with ISAAC/VLT measurements at z~1 (Figure 1). They find an increase of a factor of 12 in comoving Hα luminosity density from z=0.2 to z=1.3 and confirm a strong rise of SFR at z>1.3 proportional to $(1+z)^{4.1\pm0.3}$.

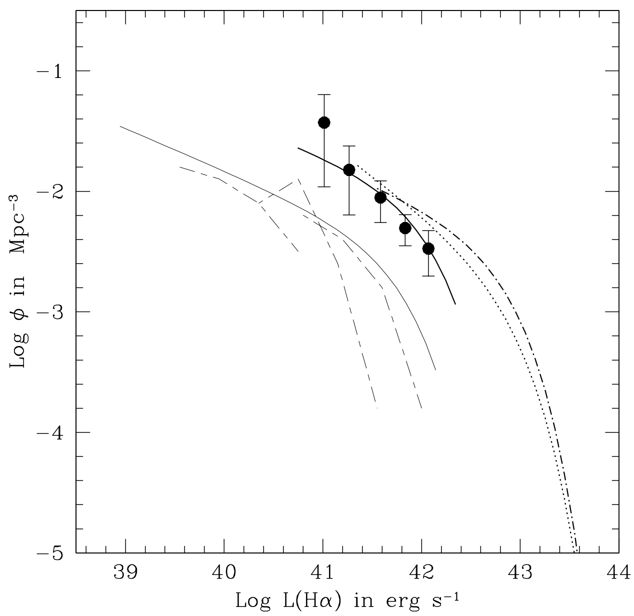


Figure 1. The evolution of the Hα luminosity function with redshift, taken from Tresse et al. (2002; Fig 13). The filled circles are the data points from their ISAAC/VLT survey. The short-long dashed curves are the preliminary Hα LF from Jones & Bland-Hawthorn (2001) from left to right respectively at z=0.08, z=0.24 and z=0.40.

The TTF has also been used successfully to unambiguously identify faint cluster members, especially those with emission. As an example, in one cluster at z=0.45, in 2 hours and 2" seeing, 10 cluster members were identified, as compared to 6 members in 1.5 nights using the Keck LRIS spectrograph (Dalcanton 1996; Zaritsky et al. 1997). At higher redshift, Francis et al. (2001a,b) look for Lyα emission from star forming galaxies within an ensemble of galaxies at z=2.38 originally identified from damped Lyα absorption at the same redshift in a paired quasar sightline.

Energetic Gas in Clusters

There have been claims of EUV excesses in clusters which, if true, would suggest that 10^{5-6}K gas accounts for a large fraction of missing baryons (Lieu et al. 1999; Bowyer et al. 1999). EUV emission is exceedingly difficult to detect at Earth: it is too hot to be detected optically, too cool to be seen by x-ray satellites, and undergoes molecular line absorption as it propagates through the ISM.

Using the EUVE satellite, Lieu et al. (1999) claim a direct EUV detection of the cluster Abell 1795. Maloney and Bland-Hawthorn (2001) found that such a strong EUV field would ionize the molecular and HI disks of all the spirals in a cluster to such an extent that they should all be Hα bright. TTF observations of the cluster were kindly taken by Edge in "straddle shuffle" mode in order to subtract the continuum light of the cluster very accurately. Only very faint Hα emission was found in the cluster spirals.

Jaffe and Bremer (2000) used "on-off" charge shuffling in order to detect very faint levels of Hα emission in cooling flow clusters. In the case of Abell 2597, they find a nebula extending over 50 – 60 kpc from the cluster centre. Edge and collaborators have looked at a large sample of cooling flow clusters and detect optical line emission in all cases. Johnstone and collaborators have begun a campaign to detect very highly ionized gas from ions like [FeX].

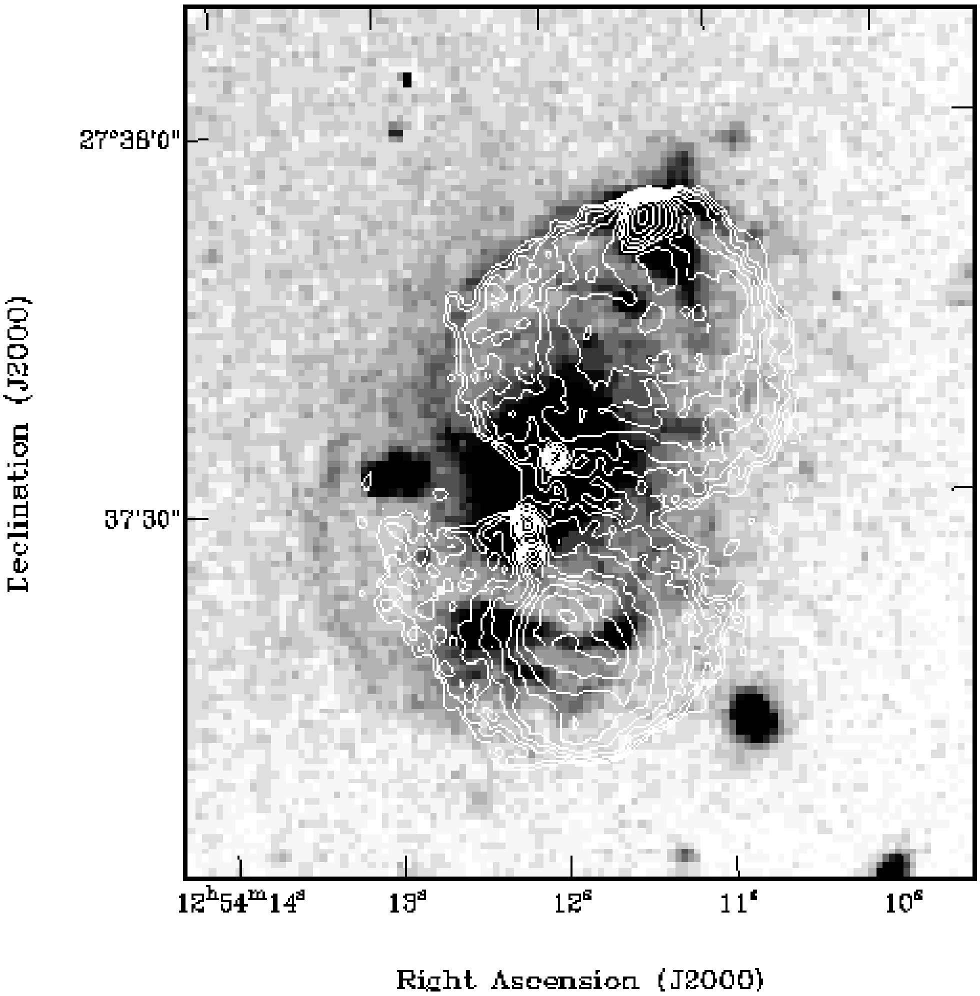


Figure 2. The optical emission from radio galaxy Coma A (Tadhunter et al. 2000, Solorzano-Inarrea et al. 2002) showing the correspondence between the outer nebula and the extended radio lobe.

Radio Galaxies

Tadhunter and collaborators have undertaken a comprehensive survey of extended ionized haloes around powerful radio galaxies (Tadhunter et al. 2000; Solorzano-Inarrea et al. 2002). They confirm that the optical line emission often aligns with the radio axis in all their targets, but more surprising was the frequency of optical emission perpendicular to the radio axis. In Figure 2, the optical emission in Coma A extends over > 150 kpc in an egg-shaped nebula, and the faint outer nebula emission matches the extended outer radio lobe over these same scales. This correspondence cannot always be ascribed to shocks, as in the case of low power radio jets, the emission is thought to arise from synchrotron, while in high power radio jets, the x-rays are produced by inverse Compton emission (Birkinshaw et al. 2001).

Quasar Nebulae

Shopbell et al. (1999) have detected an extended nebula surrounding the x-ray selected quasar MR 2251-178. The summed image in Figure 3 is one the faintest extended emission-line images ever published. The nebula extends over more than 200 kpc and shows pronounced tidal structure. The entire structure appears to be in rotation about the quasar. UV radiation from the quasar would have to be escaping almost isotropically to account for the ionization. Both the source of the gas and the source of ionization remain a mystery.

Seyfert Galaxies

Seyfert galaxies offer the possibility of using the ISM of spatially-resolved galactic disks to investigate the hidden nuclei. NGC 1068 is known to contain a concealed Seyfert 1 (“low power quasar”) nucleus, but how

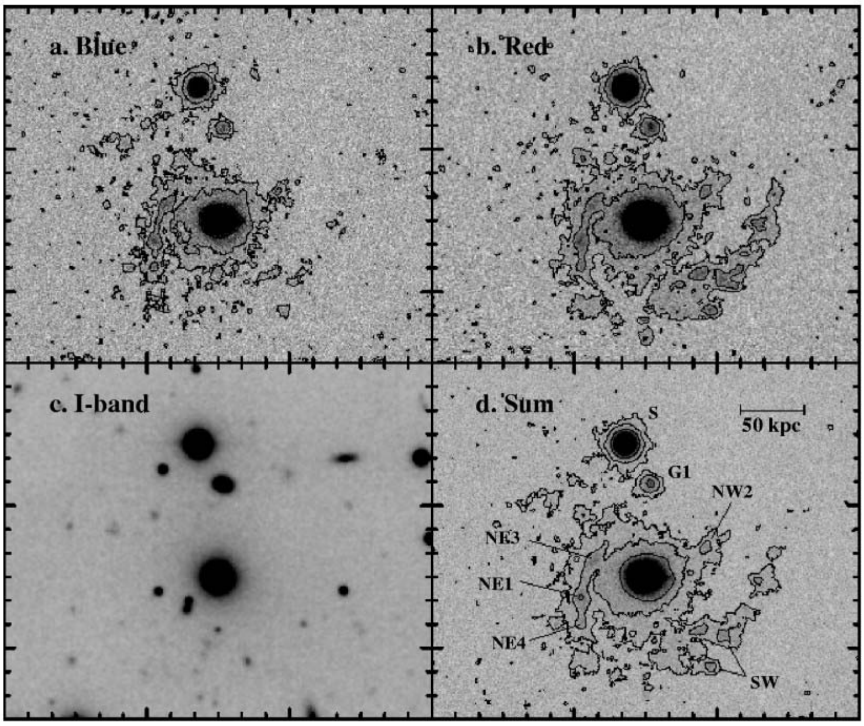


Figure 3. The extended ionized nebula surrounding the x-ray selected quasar MR 2251-178. The top figures show deep TTF Hα images in two closely-spaced narrow bands in order to emphasise the kinematic structure. The summed emission (bottom right) is seen to extend over 200 kpc or more. The stellar continuum image is also shown (bottom left).

energetic is the source? Shopbell et al. (2001) find that the well known ionization cone (Pogge 1988) extended up to and beyond the HI edge of the early-type spiral. This requires rather special conditions, and the most likely explanation is that a multi-phase, vertically distended ISM is being blasted by a highly energetic central source with $L_{uvx} > 5 \times 10^{43}$ erg s^{-1}.

A number of groups have found galaxy-scale ionization cones in other Seyfert galaxies. In particular, Circinus, a large spiral close to the Galactic plane, shows evidence of a whole network of "artillery shells" blasting away from the nucleus (Veilleux & Bland-Hawthorn 1997). One filament shows a spectacular "Herbig Haro"-like morphology. Extended ionization cones are also seen in radio galaxies. Hawthorn has observed Cen A in [OIII] (Figure 4) using the "straddle shuffle" mode to achieve a clean subtraction of the elliptical galaxy. We see a very highly ionized halo of [OIII] emission above and below the dust lane (first found by Phillips et al. 1984). We suspect that this emission comes from a highly ionized wind which encompasses the radio jet over a much larger solid angle.

Disk-Halo Connection in Spirals

For his thesis work, Miller (2002) is undertaking an emission line survey of edge-on spiral galaxies in order to trace the connection of disk star formation with activity in galactic haloes. Miller and Veilleux (1999) and Veilleux (2001) show spectacular examples of diffuse ionized gas several kiloparsecs off the plane of normal spirals. The ratio maps show enhanced [NII] emission with respect to Hα as we move away from the plane which is most easily explained as a higher electron temperature in the halo gas (cf. Sokolowski 1993; Reynolds et al. 1999; Collins & Rand 2001). The source of the temperature increase is a topic of debate in contemporary astrophysics.

Star Formation in Elliptical and Spiral Galaxies

Very little is known about the frequency and nature of star formation in the earliest types of galaxies, even though we have known for a long time that a large fraction contain cold gas (van Gorkom 1997; Knapp 1999). Ferguson et al. (2001) have been making Hα measurements with TTF of a large sample of HI-selected ellipticals. Essentially all of these systems to date show evidence of star formation.

NGC 2915 is a dark matter dominated, blue compact dwarf galaxy with an HI disk extending to a radius of 15 kpc. In optical continuum, it is relatively nondescript with an optical radius of only 3 kpc. No stars were known to exist beyond this radius. Meurer et al. (1999) obtained deep Hα imaging with the TTF revealing for the first time faint HII regions at projected radii of 3 to 6 kpc. Higdon et al. (1997) have made a multi-line study of the Cartwheel galaxy. This is the most spectacular of the class of "ring galaxies" which are excited by the central impact of an interloper. They identify up to 100 star forming regions throughout the disk which they model as propagating star formation.

Galactic Sources

A number of projects have been carried out with TTF on Galactic sources. Jones et al. (2002a) have discovered an extended Hα nebula associated with a pulsar moving rapidly through the ISM. Schuberth and Burton (2000) have observed the [CI] λ8727 line to identify photodissociation regions (PDRs) in NGC 2023, an HII region on the surface of a molecular cloud.

There is presently a lot of interest in detecting variability from brown dwarfs. If the atmospheres and environs are cool enough, models suggest that there should be dust condensations which swirl around the brown dwarf producing variability in the light curve. This was detected for the first time by Tinney and Tolley (1999) in the M-type brown dwarf LP 944-20 by using TTF in a novel way, stepping the CCD in time with the TTF tuning between bands. They have since found a second example, Kelu-1 (Clark, Tinney & Covey 2002). These sources do appear to have complex weather patterns.

Conclusion

This review covers only a sample of the projects which have made use of the TTF over the past five years. Rather than being a specialist instrument, the TTF has a wide range of applications which are still far from exhausted. An extended review of TTF science has been submitted to PASA.

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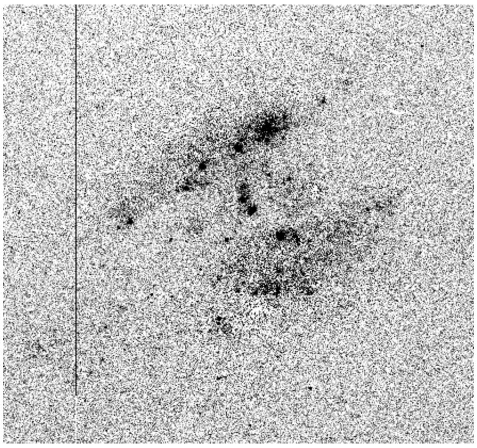


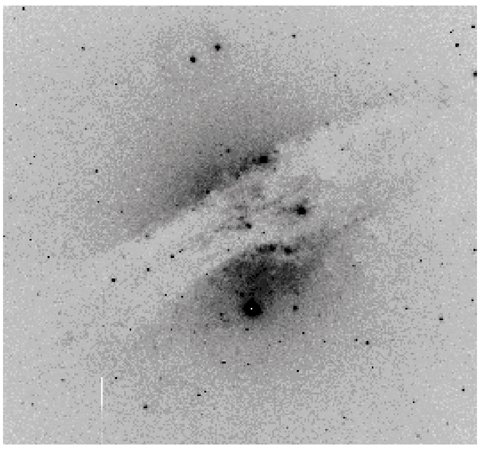


Figure 4. Left – Short exposure of the [OIII]500.7nm emission-line halo seen above and below the dustlane in Cen A, obtained with the "straddle shuffle" mode using the TTF (see text). These are raw data: the bad column arises from trapped charge during charge shuffling. Right – Line + continuum image of Cen A to emphasise the dust lane.

NEWTON'S TELESCOPE AND THE HALF-FILLED BATHTUB

Fred Watson (AAO)

Visitors to the *Mars and Beyond* exhibition currently showing at the National Museum of Australia may have noticed the Royal Society's replica of Newton's first reflecting telescope prominently on display near the exhibition's entrance. Although it bears an ancient plaque declaring it to have been '*…inuented bi Sr. Isaac Newton and made with his own hands in the year 1671…*', this instrument is now thought to be an eighteenth-century copy (see, e.g., Bishop 1980).

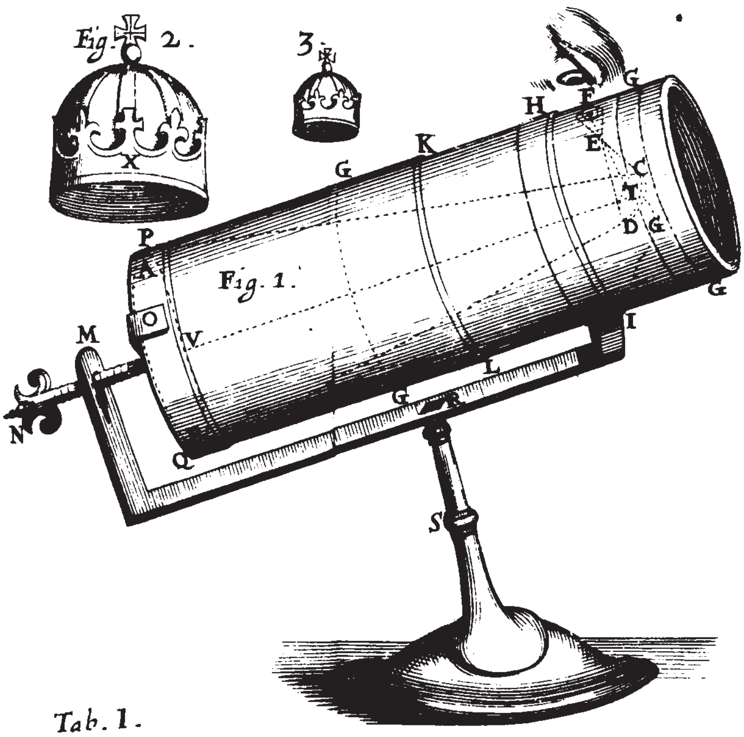
Most readers of the *AAO Newsletter* will know that Newton produced the first working reflecting telescope in 1668, and set in train the lineage that includes the AAT — not to mention the Geminis and VLTs of this world. But Newton's telescope was a very late arrival on the seventeenth-century optical scene. Refracting telescopes had been around since 1608, when they emerged from obscurity in the hands of a brace of Dutch spectacle-makers (van Helden, 1977a). By 1668, they had become relatively sophisticated, their large focal ratios and compound eyepieces having gradually evolved over the previous thirty years (van Helden, 1977b). And only two years later, the enterprising brewer Johannes Hevelius unveiled the seventeenth-century's Overwhelmingly Large Telescope in the shape of his monstrous 46-m long refractor (King, 1955, Chapter 4). These developments had taken place as a result of continuing experimentation rather than any sound theoretical understanding. But they did work, and allowed astronomers to ply their trade reasonably successfully in the era before the achromatic doublet lens made its début (in 1729).

So where had the reflecting telescope been in the intervening 60 years? The answer is that it, too, had been undergoing extensive development — but entirely in the heads of the leading mathematicians of the day. Paradoxically, while the theory of the refractor had made no real progress since Kepler's *Dioptrice* of 1611, the theory of the reflector had progressed by leaps and bounds. René Descartes was first off the mark in 1634, recognising the need for a paraboloidal rather than a spherical mirror. Then, in 1636, Marin Mersenne described all-reflecting equivalents of Galilean and Keplerian refractors, while in 1663 James Gregory proposed a 2-mirror telescope with a conventional Keplerian eyepiece. With the publication of the Cassegrain form in 1672, the range of theoretical possibilities for reflecting telescopes was so complete that no further improvement was made until the work of Schwarzschild in 1905 (Wilson, 1996, p.3).

Clearly, in the case of the reflector, theory had far outstripped practice, and one has to ask why this should be. In fact, the reflecting telescope had not been without its experimental zealots: Niccolo Zucchi had set the ball rolling in 1616, and other learned Italians had had a shot at making one soon afterwards (Danjon & Couder, 1935, pp.604ff). The problem was that none of their telescopes actually worked.

While this probably baffled the practical opticians of the early seventeenth century, it is quite easy to understand today. The reason is simply that a mirror is fundamentally much harder to make than a lens. At first sight, this looks like another paradox, given that a lens has two optical surfaces compared with a mirror's one — and a lens must, in addition, be made from optically homogeneous material. In fact, the issue of homogeneity is a relatively minor one for small lenses (even with the poor glasses available in the 1600s) and the dominant effect turns out to be nothing more than the laws of reflection and refraction.

Imagine an optical surface with a local error in the form of a tilt. This imparts a corresponding angular error to



Figures: Opposite: drawing of Newton's telescope which accompanied the first published description, from the Philosophical Transactions of the Royal Society for March 25, 1672 (Bishop 1980). Above: Newton and his telescope on the British Pound note, from http://www-history.mcs.st-andrews.ac.uk/history/PictDisplay/Newton.html.

the reflected ray if the surface is on a mirror, and to the refracted ray if it is on a lens. But the relative amounts of these errors are very different. We can easily demonstrate the disparity: let *i* be the angle of incidence at the surface, *R* the angle of reflection (for the mirror), *r* the angle of refraction (for the lens), *n* the refractive index of the lens material and ε the local tilt error. Then, if *i*, *r* are small so that $n = i/r$, we have:

$$dR/d\varepsilon = 2;$$

$$dr/d\varepsilon = 1 - 1/n.$$

For glass, $1 - 1/n$ is ~1/3, which means that an error on a refracting surface has only *one-sixth* of the effect of the same error on a reflecting surface.

For a lens with two optical surfaces the tilt errors add in quadrature, leading to the conclusion that the surface accuracy of a mirror must be about four times better than that of the equivalent lens to produce comparable (monochromatic) optical performance. We know that even in the 1640s, optical surfacing techniques were so poor that lenses bigger than about 20 mm in aperture were useless as telescope objectives (Willach, 2001). What chance had anyone of producing a telescope mirror using such techniques?

Newton's great leap forward was not the invention of the telescope that bears his name (indeed, there is evidence that the Newtonian configuration was suggested by Bonaventura Cavalieri a decade before Newton was born) but in the refinement of optical surfacing technology. He describes his methods in *Opticks* (1730 edition, Book One, Part I) and reveals himself to be a skilled optical craftsman. Newton was no slouch at the calculus either, and in the same place he makes a passing reference to the six-times greater error of the reflected ray mentioned above — just another throw-away discovery by the great man.

As a postscript to this story, here's an easily-performed practical demonstration. Half-fill a bath with water (preferably warm) and compare the reflected image of the upper rim of the bath with the refracted image of the bottom of the bath. Because the refractive index of water is only 1.33, and because we are dealing with only one optical surface, the deviation of the reflected rays by surface ripples is now *eight* times greater than that of the refracted rays. Any object on the bottom of the bath remains easy to see when the surface is disturbed, but the reflected image of the bath-side quickly breaks up into meaningless blobs. It is a striking reminder of Newton's achievement in making the first successful telescope mirror. Of course, once you put the kids in the bath, all bets are off.

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THE END OF OBSERVATIONS FOR THE 2DF GALAXY REDSHIFT SURVEY

Matthew Colless and the 2dFGRS team*

After five years and 272 nights on the AAT, observations for the 2dF Galaxy Redshift Survey (2dFGRS) were finally completed on 11 April 2002. In sum, the survey measured redshifts for 221,283 galaxies over 5% of the sky out to redshifts $z \cong 0.3$. It currently provides the largest and most detailed map of the local universe (see http://www.mso.anu.edu.au/2dFGRS).

The seed of the 2dFGRS was planted in the late 1980s, when the UK Large Telescope Panel (Richard Ellis, Mike Edmunds and Jim Hough) gave high priority to converting existing telescopes to wide-field science, especially multi-object spectroscopy. For the AAT, the case for such a conversion was greatly strengthened when Roderick Willstrop and Charles Wynne showed that, with suitable correction optics, the telescope could be adapted to permit a 2-degree diameter field of view at the prime focus (Willstrop 1987; Wynne 1989).

Seizing this opportunity to exploit its established strength in robotic multi-object spectroscopy, the AAO, under the leadership of Russell Cannon and Keith Taylor, designed a wide-field, multi-object spectrograph: the Two-degree Field (2dF) facility (Taylor & Gray 1990; Gray et al. 1993). Construction began in 1990. With massive field-correction optics including an atmospheric dispersion compensator, a pair of tumbling focal planes to minimize dead time, 400 optic fibres mounted in magnetic buttons, a fully-robotic positioning system, and end-to-end software for control, configuration, data-taking and reductions, 2dF was a truly visionary instrument.

The extraordinary capabilities of 2dF cried out for a scientific project of equal ambition. A grand redshift survey sampling a representative volume of the universe in order to measure fundamental cosmological parameters was one of the scientific drivers for the instrument from its conception. This idea was developed by the founding members of the survey team into a concrete proposal during 1993 and 1994. The first survey proposal was submitted to the TACs and the AAT Board in 1994. This proposed a survey of 250,000 galaxies down to b_J=19.5, based on the photographic photometry of the APM Galaxy Survey. It also proposed a survey of fainter galaxies to be carried out in the best observing conditions. The combined survey was estimated to require 75 clear nights (about 125 allocated nights after allowance for weather) and was projected to be completed by the end of 1996!

In fact, 2dF was placed on the AAT just in time for its official opening in November 1995, and the first spectra were taken in mid-1996. Scheduled observations with 2dF at full functionality began in September 1997, with the first major redshift survey run in October 1997. Progress with the survey was slow to begin with (Colless 1999), mainly due to problems in getting the fibre positioner to run at full speed. The 50,000-redshift mark was passed in mid-1999, but the 100,000-redshift mark was passed in mid-2000. The first 100,000 redshifts and spectra were released publicly in June 2001 (Colless et al. 2001), and the 200,000-redshift mark was achieved towards the end of 2001. The progress of the survey observations is summarized in Figure 1.

Although the survey observations are finished, the analysis of the survey is still in full swing. So far the main results to emerge have been cosmological, in keeping with the primary goals of the survey as it was envisaged a decade ago when 2dF was being built. See the centrefold on pp 18-19 for a list of the highlights.

Many of these results were explicit goals of the survey as it was originally proposed, but some were not foreseen (or at least were under-appreciated). The original focus in measuring the power spectrum of the galaxy distribution was on distinguishing between dark matter models (CDM and its rivals), and measuring the mass density of the universe through the power spectrum shape parameter (Ωh); the possibility of detecting the acoustic oscillations due to baryon/photon coupling, and so measuring the baryon fraction, was overlooked.

Similarly, the conventional wisdom of a decade ago discounted a cosmological constant, so that its determination through combining the redshift survey with the remarkable progress in the measurement of CMB anisotropies was not considered. And of course a decade ago neutrinos were still widely held to be massless, so that measuring their mass did not feature in the original survey proposals.

Other goals of the survey, such as the direct measurement of the absolute value of the bias parameter for galaxies (as opposed to the relative bias parameter for different types of galaxies), were explicitly proposed, but were considered by many to be over-ambitious. The

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***The 2dFGRS team:** Ivan Baldry, Carlton Baugh, Joss Bland-Hawthorn, Sarah Bridle, Terry Bridges, Russell Cannon, Shaun Cole, Matthew Colless, Chris Collins, Warrick Couch, Nicholas Cross, Gavin Dalton, Roberto De Propris, Simon Driver, George Efstathiou, Richard Ellis, Carlos Frenk, Karl Glazebrook, Edward Hawkins, Carole Jackson, Bryn Jones, Ofer Lahav, Ian Lewis, Stuart Lumsden, Steve Maddox, Darren Madgwick, Peder Norberg, John Peacock, Will Percival, Bruce Peterson, Will Sutherland, Keith Taylor.

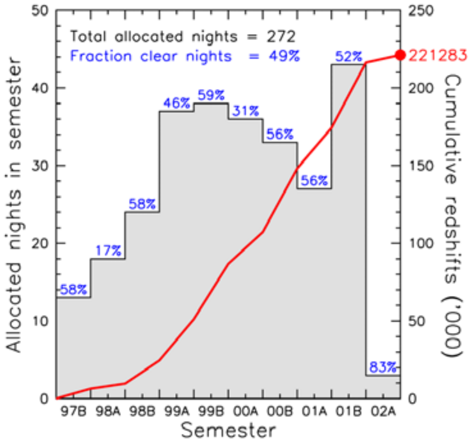

Figure 1: The progress of the 2dFGRS. The red line shows the cumulative number of redshifts (right axis). The histogram shows the number of allocated nights in each semester (left axis). The blue numbers are the fraction of clear time in each semester.

successful achievement of these goals is therefore doubly satisfying.

The cosmological parameters measured from the 2dFGRS have made a significant contribution to shaping the consensus model for the fundamental properties of the universe that has emerged from a range of independent observations, also including the measurements of the CMB anisotropies, the distances to high-redshift supernovae and Big Bang nucleosynthesis.

Alongside these cosmological results, the 2dFGRS is also yielding a wide range of results on the properties of the galaxy population, and providing strong constraints for models of galaxy formation and evolution. Highlights so far in this area include:

- The best determinations to date of the optical and near-IR galaxy luminosity functions (Cole et al. 2001; Norberg et al. 2002).
- The detailed characterization of the variations in the luminosity function with spectral type. (Folkes et al. 1999; Madgwick et al. 2002).
- A preliminary determination of the bivariate distribution of galaxies over luminosity and surface brightness (Cross et al. 2001).
- The first precise measurement of the dependence of galaxy clustering on both luminosity and spectral type (Norberg et al. 2001, 2002).
- A constraint on the space density of rich clusters of galaxies from the velocity dispersion distribution for identified clusters (De Propris et al. 2001).
- Separate radio luminosity functions for AGN and star-forming galaxies (Sadler et al. 2001; Magliocchetti et al. 2002).
- Constraints on the star-formation history of galaxies from the mean spectrum of galaxies in the local universe (Baldry et al. 2002).
- A measurement of the environmental dependence of star-formation rates of galaxies in clusters (Lewis et al. 2002).

These results are just a small fraction of the information that can be extracted from the 2dFGRS on the properties of galaxies and their relation to the large-scale structure of the galaxy distribution. As Winston Churchill once said: *"This is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning."*

Finally, the 2dFGRS team would like to acknowledge and thank the many people at the AAO whose extraordinary efforts have made the survey not only possible but successful: the instrument team (see Lewis et al., 2002), the two directors under whom the construction of 2dF and the survey observations were carried out (Russell Cannon and Brian Boyle); the members of the AAT Board over more than a decade, and the entire support and technical staff of the AAT.

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(A full list of publications by the 2dFGRS team is given at http://www.mso.anu.edu.au/2dFGRS.)

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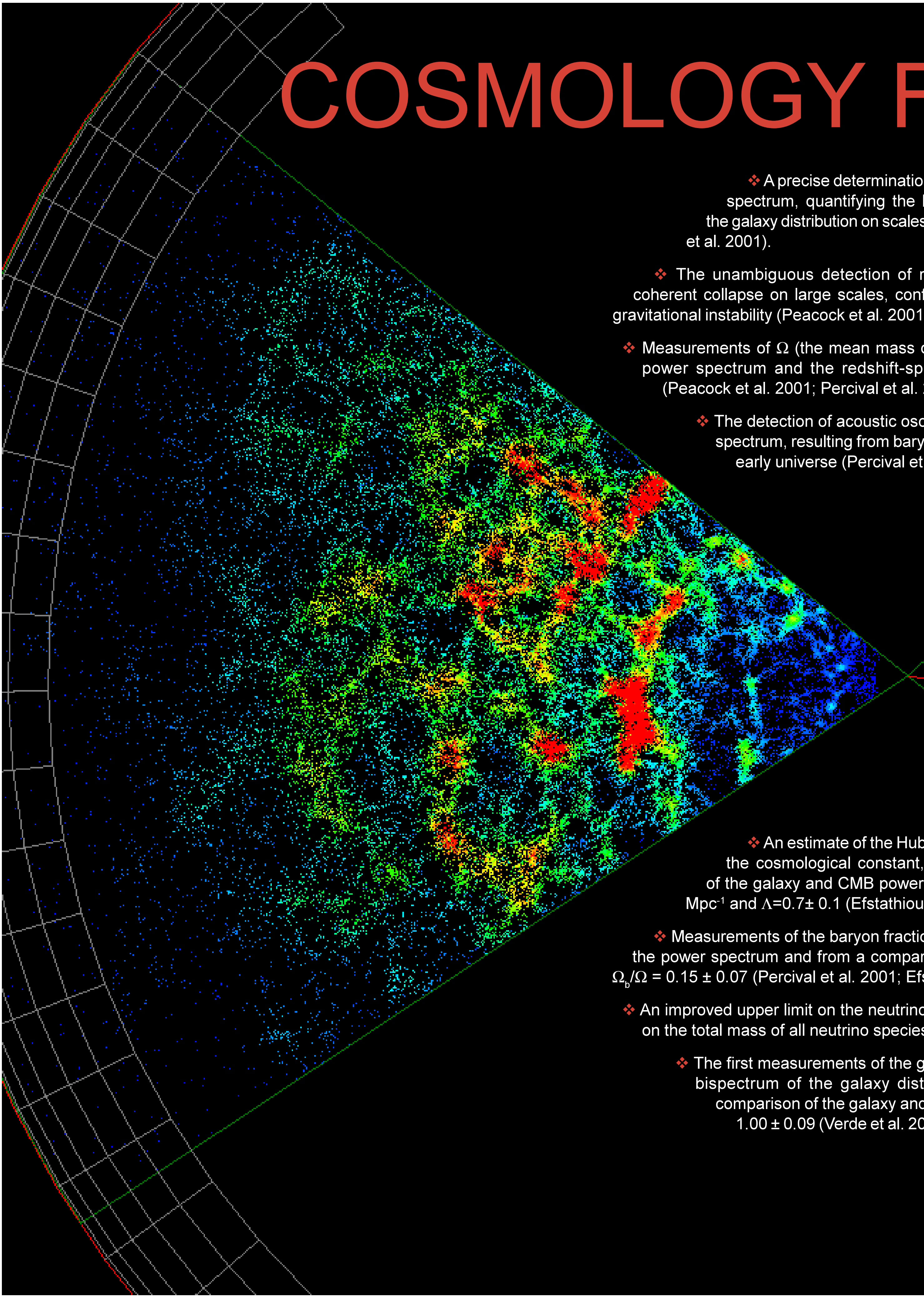

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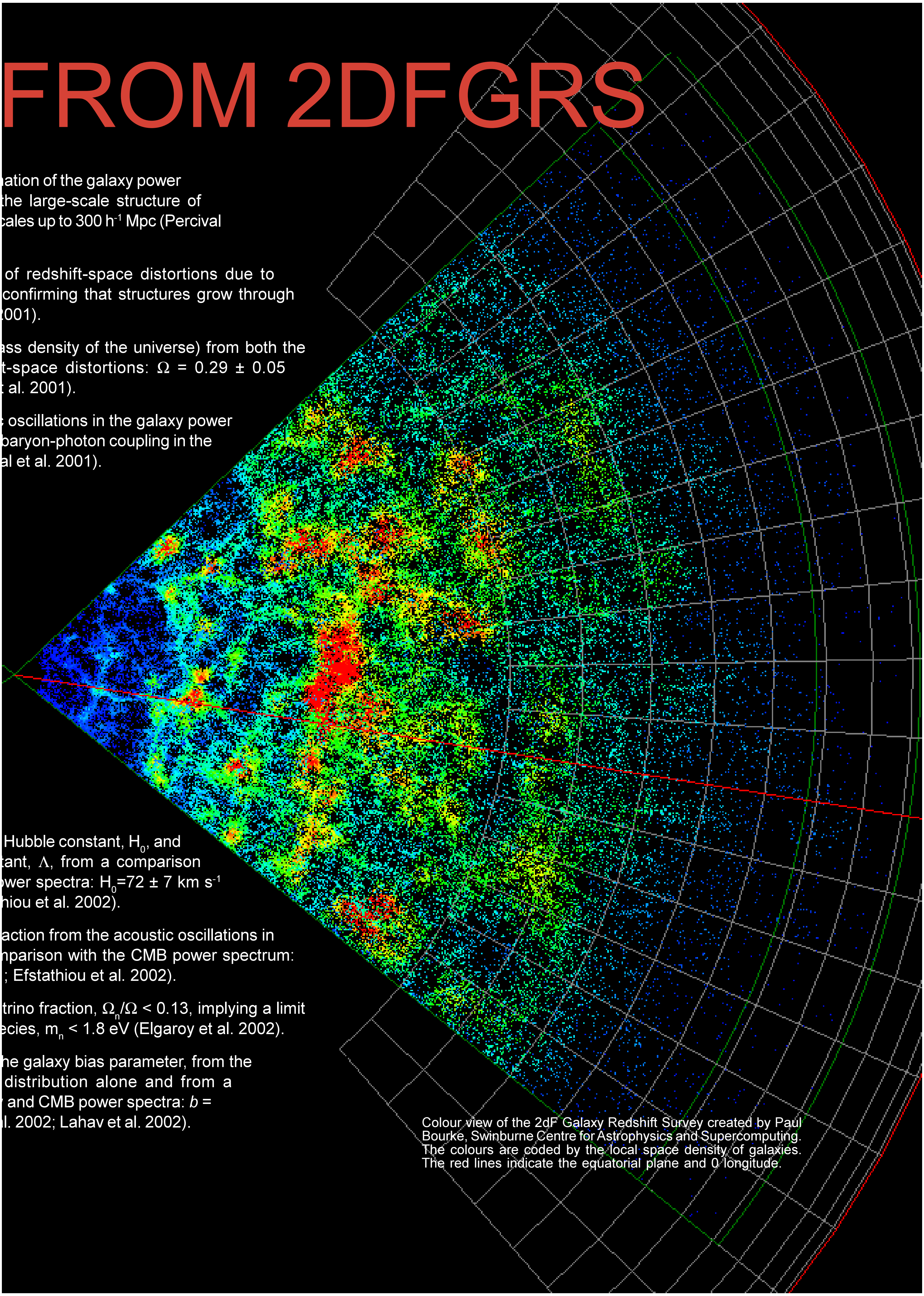

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ecies, m_n < 1.8 eV (Elgaroy et al. 2002).

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distribution alone and from a
and CMB power spectra: *b* =
l. 2002; Lahav et al. 2002).

Colour view of the 2dF Galaxy Redshift Survey created by Paul Bourke, Swinburne Centre for Astrophysics and Supercomputing. The colours are coded by the local space density of galaxies. The red lines indicate the equatorial plane and 0 longitude.

AAΩ: THE SUCCESSOR TO 2DF

Terry Bridges, on behalf of the AAΩ Team[1]

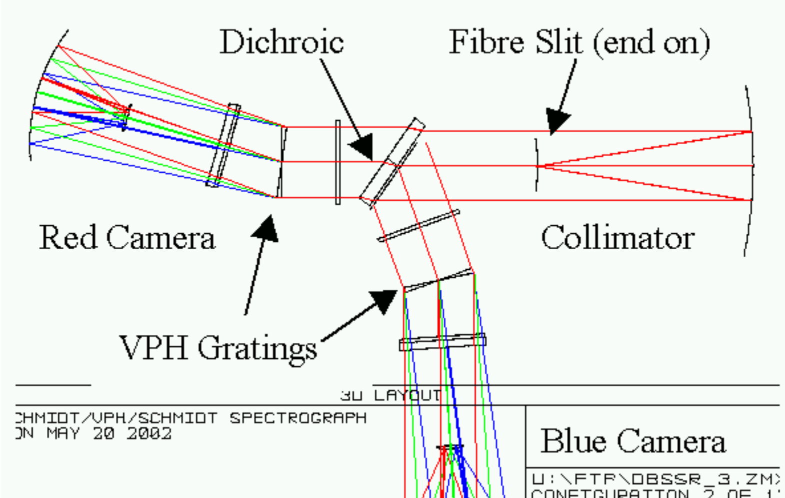


Figure 1. AAΩ Optical Layout

Figure 2. AAΩ Mechanical Layout

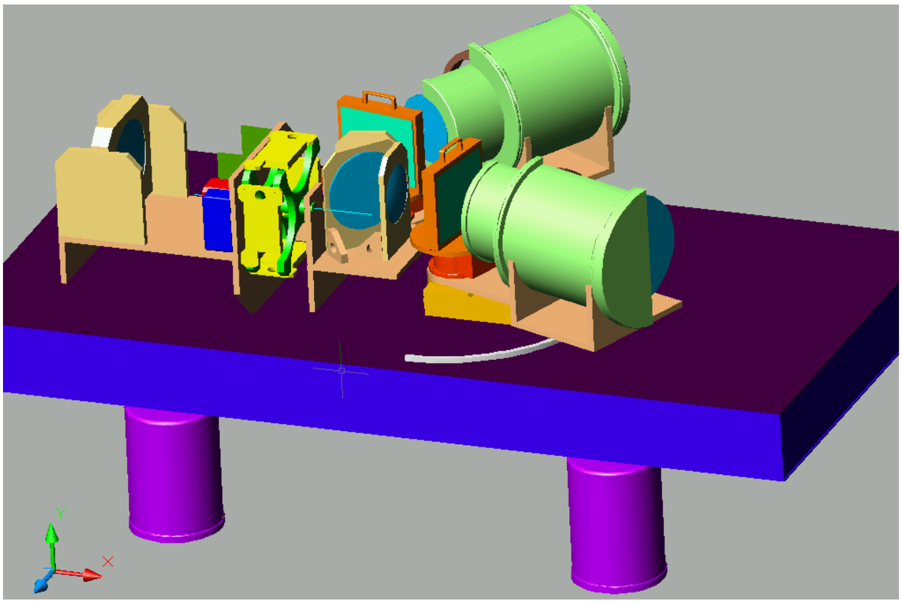
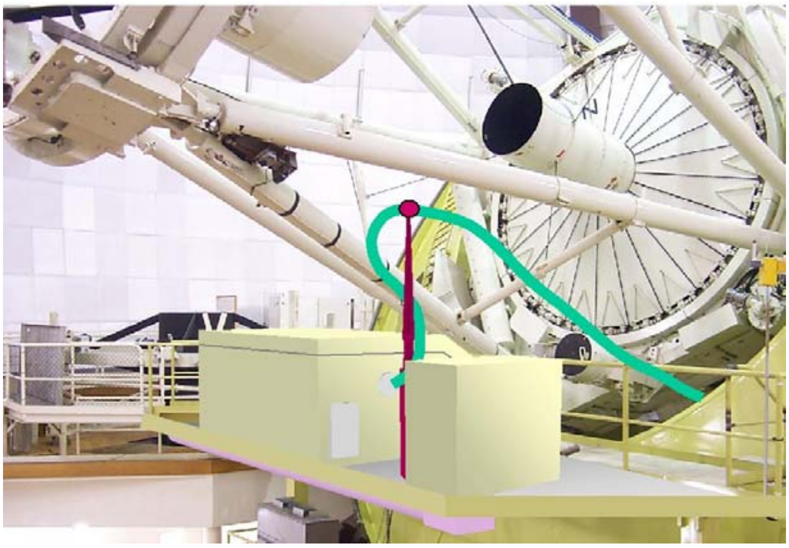


Figure 3 (below). The proposed location of the AAΩ Spectrograph on the South Catwalk.



[1]The AAΩ Team includes at present: Terry Bridges, Chris McCowage, John Dawson, Tony Farrell, Gabriella Frost, Roger Haynes, Allan Lankshear, Jonathan Pogson, Will Saunders, Greg Smith, John Stevenson and Lew Waller. Peter Gillingham (AAO), Damien Jones (PrimeOptics) and Gordon Robertson (USydney) have also been very involved in the project, as well as other AAO staff.

AAΩ will be the successor to 2dF[2], and the next generation optical spectrograph for the AAT. It will retain the wide field of view and large multiplexing capability of 2dF, while also providing single object integral field capability. AAΩ will consist of a new stable, bench-mounted spectrograph fed by new Heraeus multi-object fibres from a refurbished 2dF positioner, and IFU fibres from the existing SPIRAL instrument. AAΩ will provide much higher spectral resolution (x3–x4), throughput (~ x2), and stability than the existing 2dF instrument, enabling science that is simply not possible with 2dF, or other instruments on 4-m or larger telescopes.

Description of AAΩ

Refurbished 2dF Positioner

The basic 2dF positioning system will not be changed, but upgrades will be made to improve its reliability and functionality. These include: improvement of the gripper unit and gantry; refurbished retractors; and new, flatter field plates. See also the article on p9 describing the recent implementation of 2dF autoguiding, and the commissioning of the first stage of 2dF plate rotation.

Multi-Object Spectroscopy

The existing 2dF corrector will be used in order to maintain the 2 degree field of view. The existing 2dF 8 m Polymicro fibres will be replaced with new Heraeus STU fibres, of ~30 m length to reach from the AAT top-end to the new AAΩ spectrograph mounted on the southern catwalk. After careful modelling, we have decided to leave the fibre diameter unchanged at 140 μm (2.0"). The number of multi-object (MOS) fibres is still to be determined, but will be between 350–390. The exact number depends on the performance of the delivered optics, and how many fibres we can Nod&Shuffle with. There will be 8 guide fibre bundles instead of the current 4 of 2dF, to improve the chances of allocating guide stars (especially at the edge of the field, where rotation corrections are most important).

IFU

The existing SPIRAL IFU will be unchanged, except for modifications to the slit unit for use with the new AAΩ spectrograph. It can be used either at auxiliary Cassegrain port with other Cass. instruments, or by itself at straight-through Cass. focus; the latter will allow spectropolarimetry, though there may be restrictions on the IFU rotation because the SPIRAL fibres will just reach the AAΩ spectrograph. The spatial sampling and field of view will be unchanged from the current 0.7" fibre and 11" x 22" respectively; this spatial sampling critically samples the median AAT seeing. Nod&Shuffle is expected to be the normal mode of operation in IFU mode, as it is for the current SPIRAL.

The AAΩ Spectrograph

A new spectrograph is at the heart of AAΩ. During the AAΩ Concept Design Study, we looked at two main options: a transmissive single beam spectrograph, and a Dual Beam Schmidt Spectrograph (DBSS). In performance and cost they came out very close, but we chose the DBSS on the basis of better image quality, and the very high risks associated with the cost, availability, complexity, and manufacture of the transmissive system. Figure 1 shows the optical layout of the AAΩ spectrograph, while Figure 2 shows a mechanical CAD drawing. Features to note:

- Thermally stable and bench-mounted on the AAT South Catwalk (see Figure 3 for how this might look).
- Slit-unit with 4 slits (2 MOS; 1 IFU; 1 calibration). Note that the calibration unit will include a long-slit with lamp for (undispersed) detector flat-fielding (not currently possible with 2dF).
- Separate blue and red arms, each with an optimized 2k x 4k CCD with 15 μm pixels, enclosed in an evacuated Schmidt camera. The CCDs will be run with new AAO-2 CCD controllers.
- F/3.15 collimator, F/1.3 camera(s)
- Removable dichroic to feed the two arms, with split wavelength at 570 nm
- Volume Phase Holographic (VPH) gratings for low, medium, and high dispersion, offering higher spectral resolution and throughput than the existing 2dF reflection gratings. The initial AAΩ grating set is listed in Table 1.
- Spectral resolution: **MOS:** 1200–8000 (lowest resolution/minimum highest resolution; see Figure 4); **IFU:** 2000–13,000 (the spectral resolution is higher in IFU mode because of the smaller fibre size). Compare with 2dF, with R_{max} ~ 4000.
- Wavelength coverage: 370–950 nm
- Articulated camera (14–90 deg), and remote control of most mechanisms (articulation, camera focussing, etc)
- Nod&Shuffle capability. At this point, we don't know how many fibres we will be able to N&S with. If built to spec., the optical quality may be good enough to allow N&S with ~350 fibres (i.e. without masking off any fibres, and "mini-shuffling" by a few

[2]The 2dF and AAΩ WWW pages are: http://www.aao.gov.au/2df, and http://www.aao.gov.au/local/www/aaomega, respectively.

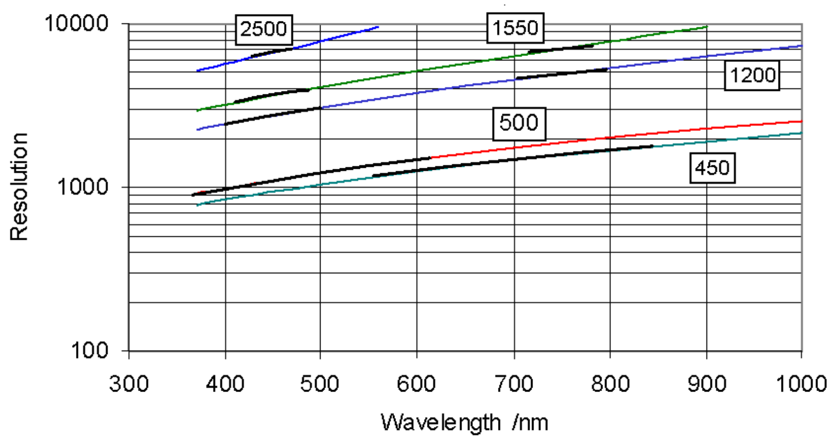


Figure 4. Spectral Resolution R=λ/Δλ attainable with AAΩ in MOS mode with four different gratings, each labelled with the number of lines/mm. The curves show the resolution obtained with each wavelength regarded as the central wavelength. The heavy lines show examples of the wavelength range that can be obtained for one setting.

pixels into the gaps between the spectra). Our fall-back position is to use a mask at the fibre input, and N&S with 200 fibres, as we currently do with 2dF.

- *Total* system throughput (both MOS and IFU modes): >10% at 400 nm, peak throughput >20% (see Figure 5). Compare with 2dF, which has a throughput <10%
- Beam size: 190 mm
- Fibre sampling at detector: 3.5/2.1 pixels FWHM (MOS/IFU)
- Sky subtraction accuracy: better than 1% rms with dedicated sky fibres, and Poisson-limited with Nod&Shuffle

AAΩ will thus have a spectral resolution 2–3 times that of 2dF, and a throughput at least double. The increased spectral resolution is largely due to the use of VPH gratings, which allow much higher line densities. The increased throughput is a combination of higher efficiency VPH gratings, more efficient CCDs tuned for each arm, and optimized optics. The improved stability (both mechanical and temperature) will also be highly beneficial for many programs, especially for observations of faint objects, where control of systematic effects is very important.

Software

AAΩ will use the existing 2dF configuration and data reduction software, `configure` and `2dfdr`, with some modifications. `configure` will be modified to make it easier to set up beam-switching configurations, where pairs of fibres need to be assigned to each object. It will also be easier to set up exactly the same configuration on both plates, which will be very useful for long integrations (the field can be reconfigured on one plate, while observing on the other). `2dfdr` will be upgraded to allow routine reduction of data taken with Nod&Shuffle and beam-switching. Currently with 2dF, psf variations across the detector are limiting the accuracy of sky subtraction in the mean-sky method. `2dfdr` will incorporate mapping of the PSF across the detector, in order to match the spectral resolution of the mean sky spectrum to that of the object spectra at any given location on the detector; the result will be greatly improved sky-subtraction.

Table 1. Details of proposed grating set for AAΩ

Arm	Grating (l/mm)	Resolution (λ / Δλ)	Wavelength Cov. (Å)
Blue Low Dispersion	580	1300	3700 – 5800
Red Low Dispersion	380	1300	5600 – 8800
Blue/Red Medium Dispersion[1]	1500	3500 – 4000	800 – 1200
Blue/Red High Dispersion[2]	3000 – 3200	~8000	~300 – 600

[1]There would be one medium dispersion grating in each arm, with 800 Å wavelength coverage in the blue (e.g. 3600–4400 Å; 4800–5600 Å), and 1000–1200 Å coverage in the red (e.g.Hα, Ca Triplet).
[2]There would be two high dispersion gratings in each arm, with ~300 Å wavelength coverage in the blue, increasing to ~600 Å in the far red. We propose to have the 4 gratings tuned for 4000 Å (stellar work), 5000 Å (Hβ, Mgb, [OIII]), 6500 Å (Hα), and 8500 Å (Ca Triplet)

AAΩ Science

AAΩ will have much higher throughput, spectral resolution and stability than the current 2dF, while retaining the wide-field and multiplex advantages of 2dF and the integral-field capability of SPIRAL. As a result, AAΩ will be one of the most efficient multi-object spectrographs on any 4-m telescope, either in terms of the total number of photons received per unit time, or the time required to cover a given area of sky. For certain applications, AAΩ will even be competitive with multi-object spectrographs on 8-m telescopes. The following are the Key Science Drivers.

Stellar Populations in Galaxies and CDM Archaelogy: Follow-up of the 2dF/Sloan Galaxy Redshift Surveys

With Matthew Colless and Joss Bland-Hawthorn, we propose to follow up the 2dF Galaxy Redshift Survey (2dFGRS) and the Sloan Digital Sky Survey (SDSS), by deriving accurate light-weighted ages and metallicities for ~70,000 galaxies. By observing 2dFGRS and SDSS subsamples with higher spectral resolution and S/N, we can start to understand the physics of galaxy formation and evolution. With the 2dFGRS/SDSS, we can select galaxies by spectral type, and compare ages and abundances for early and late type galaxies. We can also isolate cluster and field galaxies, and study the effects of environment on galaxy properties. Hierarchical merging models make predictions about the relative ages of field and cluster galaxies, which can be tested with the large samples that we propose. We will also be able to measure internal velocity dispersions (or circular velocities for late-type galaxies), giving a luminosity-independent determination of masses for comparison with galaxy formation models. This would complement very well the 6dF Peculiar Velocity Survey, which is limited to bright early-type galaxies; with AAΩ we can study galaxies of all types and with a broader range of internal velocities.

We propose to obtain spectra for ~70,000 galaxies with $B_j<19.5$, with a spectral resolution R ~ 3000 – 3500. In 2 hour exposures, we can reach a S/N ~ 50 to $B_j = 19.5$, allowing the measurement of velocity dispersions and Lick spectral indices. For $B_j<18$, the S/N will be 90–100, allowing the determination of higher resolution Hγ indices, and more precise ages/abundances via comparison with Vazdekis model spectra. With 4 fields per night, we can obtain spectra for 70,000 galaxies in ~50 nights.

Galactic Structure

There are many stellar projects where the higher spectral resolution and S/N of AAΩ will make a huge difference. With the current 2dF, the best velocity precision achievable is ~5 km/sec. With a spectral resolution double that of 2dF, plus a stable, bench-mounted spectrograph, AAΩ should achieve velocity precisions of 1 km/sec or better. The combination of higher spectral resolution and throughput will open up entirely new areas in the detailed study of stellar populations in the Galaxy and beyond.

We propose a large survey of Galactic structure, similar in spirit to that being currently carried out by Gilmore, Wyse, and Norris with 2dF (the Anglo-Australian Old Stellar Populations Survey, or AAOSPS), but with larger numbers, extending to fainter stars and larger distances, and with a more homogeneous input catalogue from the Sloan Digital Sky Survey (SDSS). The main goals here are to determine the *ages, abundances*, and *velocities* of 30,000 - 50,000 stars to V~20. This will allow a detailed delineation of the kinematics, structure, and formation of the Galactic disk, bulge, and halo (e.g. Gilmore & Wyse 2001, astroph/0104242).

Another important goal is to search for possible substructure in the Galactic halo, as predicted by hierarchical models of galaxy formation. Numerical simulations show that the accretion of dwarf galaxies will result in *tidal streams*, which may be detected in position-velocity space. For instance, Helmi & White (1999, MNRAS, 307, 495) showed that the accretion of *one* dwarf satellite of 10^8 L_{SUN} would contribute ~30 kinematically cold streams; detection of such streams would require a sample of a few thousand stars with velocities better than 5 km/sec. There has been previous evidence for possible halo substructure (see Morrison et al. 2001, astro-ph/0111097 for a summary), most recently by Yanny et al. (2000, ApJ, 540, 825) from SDSS photometry (most likely associated with the Sagittarius dwarf). The "Spaghetti Survey" by Heather Morrison and collaborators (e.g. Morrison et al. 2001), is searching for halo streams via pencil-beam photometric surveys. Follow-up multi-object spectroscopy is needed to confirm distant halo red giant candidates from this survey; AAΩ is well-suited for this, because the density of candidate halo giants is low, only ~4 giants/square degree.

We propose to obtain spectra for ~35,000 stars to V=20, selected from the SDSS and other surveys (e.g. the Spaghetti Survey), which will extend as far as 50–100 kpc into the Galactic halo. With the highest AAΩ spectral resolution (R ~ 8000), velocities of better than 5 km/sec will be easily achievable with a S/N > 20. Exposures of 4 hours/field will yield the required S/N, and 50 nights will give us the necessary sample size. We will cover ~330 square degrees of the halo.

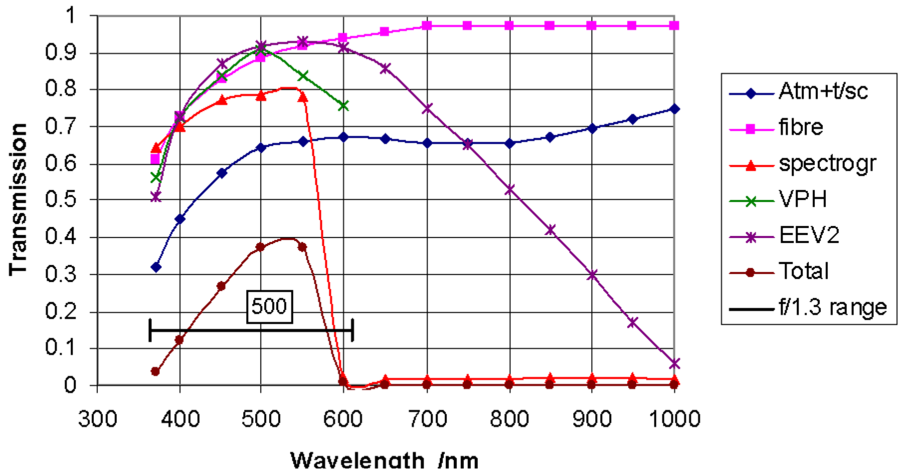


Figure 5. AAΩ system throughput in the Blue Arm in MOS mode (neglecting seeing and positioning losses). The scale bar shows the wavelength range for a 500 l/mm grating. The throughput is zero beyond ~ 600 nm, due to the dichroic cutoff at 570 nm.

Other Stellar Science

- *Galactic Globular clusters.* Large samples of high-precision velocities will allow detailed mapping of the velocity field across the whole cluster (e.g. Gebhardt et al. 2000, AJ, 119, 1268). We can also look for tidal tails around globular clusters, and search for binary stars on cluster main sequences. Higher spectral resolution and better sky subtraction will also make it feasible to measure abundances of weak elements (e.g. Na) in main sequence cluster stars.
- *Velocity Mapping of Local Group Dwarf Galaxies.* With their low velocity dispersions (<20 km/sec), the kinematic study of nearby dwarf galaxies requires velocity precisions of a few km/sec. The kinematics, in combination with numerical simulations, will reveal whether these dwarfs are dark-matter dominated or in unsettled dynamical states.
- *Intra-Cluster Planetary Nebulae.* The study of intra-cluster PNe, i.e. those PNe not attached to any cluster galaxy, is important for the determination of the amount and distribution of intracluster light. Intracluster PNe are also useful for our understanding of the processes affecting cluster galaxies (e.g. "harassment", tidal stripping), and are a good probe of cluster dynamics. As an example, covering 10 square degrees of the cores of the Virgo and Fornax clusters would yield 10,000–15,000 intracluster PNe, and require ~50 nights of AAΩ spectroscopy (K. Freeman, private communication).

IFU Science

IFU Science could include: a major study of nearby galaxies, as IFU observations are required for obtaining detailed, two-dimensional information on the kinematics, ages, and abundances of nearby galaxies; ISM ionization and kinematics (Galactic HII regions, PNe, SNRs, YSOs); targets with complex backgrounds (SNe, LMC/SMC, Galactic Plane); and spectropolarimetry (only available in IFU mode) of symbiotic stars, white dwarfs, CVs, hot stars, pre-main sequence stars and AGN.

Conclusions

AAΩ will offer high throughput, spectral resolution, stability, and improved sky subtraction, allowing projects that are simply not possible with 2dF, or indeed with instruments on other 4m/8m telescopes. AAΩ will be ideal for targeted followup of the 2dFGRS, Sloan, and other surveys, and a major theme emerges of "Physics of the Local Universe", through the combination of "Near-Field" and "Far-Field" cosmology. A possible future upgrade for AAΩ is "multi-IFUs", which are small bundles covering a few arcsec on the sky (~20 total IFU bundles). AAΩ is now in the Preliminary Design Phase, with first light expected in early 2005.

Please see the AAΩ WWW page for more information: http://www.aao.gov.au/local/www/aaomega. We welcome feedback from the user community — please email tjb@aaoepp.aao.gov.au.

Acknowledgements:

We would like to thank all of the AAO staff who have been involved with AAΩ in any way, astronomers who have provided input into the AAΩ specification and science, the AAO Board and Users Committee for their support and encouragement, and the AAΩ External Review Committee (Sam Barden, Matthew Colless, and Kieran Greene) for their valuable contribution.

HISTORY

Sandra Ricketts

Issue 100 seems like an appropriate occasion to look back over the history of the AAO Newsletter. There was an item entitled "Reminiscences" in issue 50, so this one will cover the second 50 issues.

The newsletter's first issue was in April 1977, and consisted of 5 pages stapled together at the corner (This issue has 36 pages!). Its appearance has changed too – the early issues had a banner across the top of the first page showing Centaurus and Monoceros. With issue 30 the banner changed to Argo navis and David Malin wrote amusingly about this change.

The Director's message was on the cover for the first 4 issues, but since then has followed a picture of some kind. Occasionally the cover has been in colour, with issues 57 and 61 showing an IRIS image and postage stamps with AAO images respectively. Issue 93 had a centrefold of a still from the 2dF movie.

By 1997 it was felt that the newsletter needed a facelift, and with the aid of more modern technology and desktop publishing a completely new design was created. Issue 81 (again with a colour cover) was the first in the new format, which is still much the same, although the number of pages has grown.

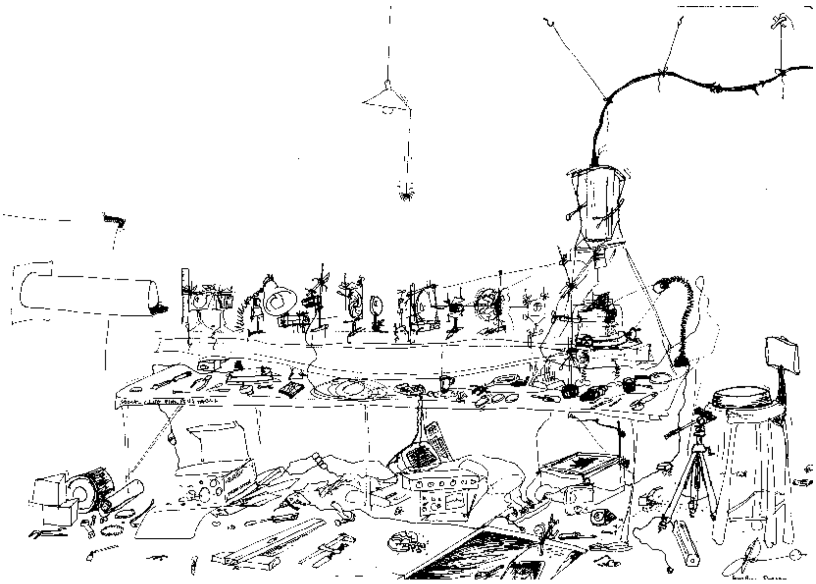
Hey fellas, it's the Night Assistant! Heads down and nobody jump till you see the whites of his eyes!

There have been 10 editors over the years, the longest serving being David Allen (19 issues) and Elaine Sadler (18 issues).

The newsletter has been available electronically at www.aao.gov.au/library/news.html since 1994, originally as postscript files, then in HTML, and now as PDF. Readers who look at both the electronic and hard copy versions will notice that there is more colour in the electronic version!

The extracurricular competitions and puzzles have continued to appear on occasion. Several crosswords have appeared in recent years, but alas have not generated much response, despite the award of a prize (not a free subscription!) There have been various cartoons, notably the one below of Peter Gillingham's desk (issue 62), midnight access to 2dF (issue 64), and the roos waiting for the night assistant (issue 94). This latter cartoon should actually have a wider circulation, as a warning to all those who drive in the Australian countryside after dusk.

There are more illustrations nowadays, mainly astronomical ones naturally, but also numerous ones of various observatory identities, instruments and pieces of equipment, not to mention the occasional wildlife specimen (tawny frogmouths, magpies, pandas…).



AAO NEWSLETTER

WALKS ON AND AROUND SIDING SPRING (AND EPPING)

Issue 24 in January 1983 saw the first in a series of items by David Allen on various walks around the telescope and Warrumbungles area. These 14 walks, with the addition of maps and other items, were eventually compiled by Robyn Shobbrook into a small book, copies of which are still available from the librarian.

1. THE SUMMIT PATH by David Allen

First-time visitors are often impressed by the beauty of the Warrumbungle Mountains. Many endeavour to snatch a few hours outdoors in the park below, or around the mountain top. On a long stay this is to be encouraged as a break from the pressure of an observing or support run. Of course, the time available may be severely limited. This series of articles will describe a number of walks, some of which require only a couple of hours. I start with the shortest of all – a pleasant quarter-hour ramble from Siding Spring Lodge to Woorut Trig, the summit of Siding Spring Mountain. Fit it in after dinner in summer, or in the cool of a winter's afternoon.

At one time the mountain top was open to the public and a path was laid out as an alternative to the roadway. The path, which skirts the southern scarp of the mountain and gives good views into the park, gradually fell into disrepair, becoming overgrown and difficult to follow. Over the last year I have put some effort into relaying it. This involved clearing the undergrowth, and building cairns and edging stones to define it better. I believe it is now distinct when travelling in either direction. However, it will not remain so. Stonework will be demolished by kangaroos and wallabies; bushes grow back. If each user could please replace one dislodged stone or break off one errant branch, we will maintain the path.

It starts behind the Uppsala dome, as a cleared strip heading for the grass trees on the near horizon. Those who eschew road walking may reach the start cross-country from the Lodge. Beginning at the lawn outside the westernmost bedrooms, a small line of cairns leads down to the saddle. From there it is a sporting clamber up the rocks to the Uppsala dome.

The main path leads to the road end at the direction plate, a few paces from the summit trig point. In only two places is the path likely to be lost. One is where it crosses rock slabs. There the path was originally marked by splashes of white paint, but these have faded a little and look like lichen growths. I have added some cairns. The other immediately follows the rocks: the path leads up to some concrete slabs. From there, ignore the very well-made gravel trail back to the road, and prefer the narrower path heading towards the summit anemometer.

Go quietly and you may happen upon a wallaby bedded down beneath one of the trees. In spring you will find many flowering shrubs and bushes. A surprising variety of flora make their home on Siding Spring Mountain: Graham Bothwell is giving some thought to labelling many of the species to convert the path into a nature trail. Of course, such activities get fitted into spare hours on busy site trips, so this may take a while.

April 1984 saw a slightly different walk described by John Storey in the newsletter.

WALKS IN AND AROUND EPPING: 1. The pub via Epping Highway by John Storey

In this new series I shall describe some delightful expeditions from the Epping Laboratory. Such walks are appropriate for those inevitable days when the VAX is overwhelmed with Taurus users, the latest copy of Ap.J. has vanished, and you've just dropped a sky survey plate. I start with perhaps the most enjoyable walk of all: the Pub.

Leaving the AAO building, ask Judy to tell all callers you are at a meeting. Head towards the Radiophysics canteen; if necessary, reassure your stomach that your destination lies elsewhere. A rather tricky climb, with loose footholds, takes you over the roof of the Cloud Physics building. The less adventurous may eschew this route, preferring as I do the slightly longer detour around the side of the building. From there, a carefully maintained path leads through the undergrowth to a gate onto Pembroke Street.

We turn left along an ancient road, and head towards the electricity substation. A harsh rumble, and delicate wisps of smoke from the transformer, are the tell-tale signs that yet another Taurus data cube is being processed by the VAX.

Performing an extrapolation of the road, we proceed into over-grown grassland. Remember that this area of Sydney is notorious for its infestation of funnel web spiders (genus: Atrax). A single bite from this obnoxious little arachnid can be as painful as a two-hour lecture on stellar magnetospheres. As you emerge, turn left onto Epping Highway. Do not attempt to cross it. One of the better surfaced roads in the area, it is a favoured haunt of those who value speed above peace and quiet. We proceed with caution, following the highway down over Terry's Creek.

The first set of traffic lights marks the intersection with yet another piece of Pembroke Street. Pause a while to reflect on the decrepit state of Sydney's so-called road system, as you watch weary motorists turning here to avoid the horrors of the Epping Railway overpass. On this occasion we will not follow their example, but continue along the highway, over the overpass and into the shopping centre. To our left a facade of shop-fronts rises to a crescendo at the brick edifice of the Pub.

Our return to the AAO retraces our steps. The climb up from Terry's Creek is steep however, and it would be irresponsible to risk dehydration and sunstroke on this section by starting back without adequate preparation.

(There was an editorial note following this item that it was the last of the series.)

ANGLO-AUSTRALIAN TEST

This was first published in issue 35, in 1985, and was designed to measure the cultural spread between the two nationalities. It would be interesting to see how those of neither Anglo nor Australian origin fare. The answers and rules for scoring are given later in this newsletter: don't cheat!

1. What are green grocers, black princes and yellow mondays?
2. "Build it up with silver and gold". What is it?
3.What is a jumbuck?
4. What would you be doing going round the traps?
5. Where would you be in the gloaming?
6. What is or was a furphy?
7. What are blackfellows' buttons?
8. What made Offa famous?
9. What do becks, brooks and ghylls do?
10. What is a stunned mullet?
11. What were a deener, a trey and a zack?
12. Can you eat codswallop?
13. Who or what are the Swallows and the Amazons?
14. What is a ringer?
15. If you have no brass razoo, what are you?
16. How would you use scouse?
17. What made Walter Gabriel famous?
18. What is Paterson's curse?
19. What word rhymes with Cholmondeley?
20. What is the chunnel?
21. What is the Shropshire Union?
22. Who was Thunderbolt?
23. What are wapentakes and hundreds?
24. What is Whitsun?
25. What is the magic pudding?
26. What is Buckley's?
27. Who was Cuddlepie's companion?
28. What is a fen?

Dome Air

Jonathan Pogson

Just when you thought it couldn't get any colder in the AAT dome, the Board has decided that we should whack an enormous great air conditioning system deep within its bowels (in the process handing Coonabarabran its latest and greatest tourist attraction, the Big Igloo, or B'igloo for short). Although feeding a computer 7 years of bad-luck seeing v. temperature data tells more lies than a blind night assistant taking seeing measurements, Alison Offer valiantly extracted the grain of truth, and finally established what we've suspected all along – warm dome bad, cool dome good.

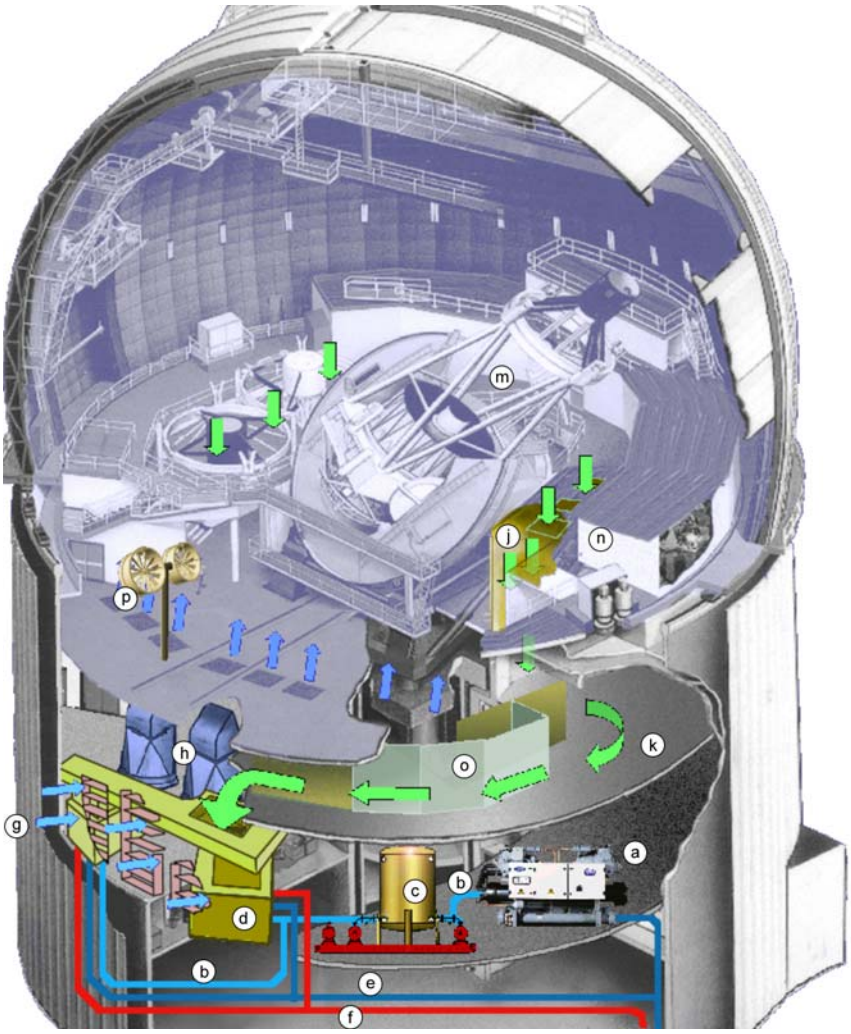
The Dome Air project is the largest and most ambitious component of our Seeing Program to date. The goal of the Seeing Program (also known as the "One Arc-second Program") is to optimise the dome seeing at the AAT, reducing the median seeing from 1.5" to 1", or at least doubling the number of nights the AAT experiences sub-arcsecond conditions. We have made significant progress towards this goal during the past decade, the most notable improvements being achieved by Auto-Venting in 1994, and Oil Cooling in 1999. Following these the decision was made to actively cool the primary mirror, but the risk of dewed mirrors in moist conditions forced us to control humidity first. Dehumidification could most effectively be done by air conditioning the entire dome, with the highly desirable benefit of solving our temperature problems in the process, so the Dome Air project was born. We expect our new dome air conditioning system will produce the most effective reduction in dome seeing since Peter Gillingham's installation of the axial fans in 1980.

The primary function of the Dome Air system is to set the temperature of the AAT dome environment during the day to match the predicted outside temperature of the following midnight. Its secondary task is to prevent dew forming on cool surfaces (such as the mirror) while observing in humid conditions. Its third function is to minimise temperature *differentials* within the dome that may be introduced by local heat sources or lagging thermal masses (such as the steelwork of the telescope). Its fourth task will be to reduce any remaining lag between the dome and a falling ambient temperature *while observing*. Finally, the system should run efficiently at all expected temperature ranges from summer to winter, and most importantly, satisfy all these demands without introducing its own problems that could degrade the seeing — not an insignificant challenge for an air conditioning system!

As each of these functions requires novel design and control features, and as we did not want to lose any of our existing facilities for venting etc, achieving such conflicting requirements within the constraints imposed by costs and the building has been an interesting challenge to say the least. Nevertheless, we have achieved a design which satisfies all of our criteria, and most remarkably, for a fraction of the cost the project is really worth. This happy outcome is possible mainly because the AAT dome was originally *designed* to be air conditioned, and much of the heavy expensive infrastructure is in place.

The Dome Air conditioning system will essentially operate in two modes, one tailored for observing in poor conditions and the other for daytime dome preparation. In good steady conditions the system will have already optimised the dome and telescope temperatures and there should be no need to run the system at night. Mechanically the plant also operates in a summer and a winter mode, although this should be transparent to the user. The Figure opposite shows the main components of the system.

A new Carrier chiller (a) with 120kw cooling capacity will super-chill a glycol solution (b) to –8° C for winter operations. This coolant is pumped to a 1000 litre storage tank (c) which provides mass to the system to assist smooth temperature control and reduce power cycling of the dual compressors. The coolant is then circulated through a pair of triple stage fan coil units (d) that can chill the dome air below freezing if so desired. Building chilled water (e) at 7° C is then used to remove the heat from the Carrier chiller, and also runs directly to the fan coil units because for summer operations there is no need to use the super-chilled glycol system. Dehumidification will occasionally require reheating of the air, in which case building hot water (f) is also piped into the fan coil units. The conditioned air is then injected into the main fan room where it can be thoroughly mixed (with a controlled amount of outside air (g) if desired) before being blown into the dome by the existing main fans (h) via the 3rd floor plenum chamber. All water and air flows will have infinitely variable PID loop controls to ensure very fine control over the final temperature and velocity of the air delivered to the dome. The Night Assistant may also choose to over-ride the system and simply vent the dome with outside air exactly as we have done since 1980.



also be programmed to systematically flush out areas that are unlikely to experience steady airflow, such as the north journal. The ultimate option is to configure these fans with IR sensors to actively "seek and destroy" relative hot spots anywhere within the dome (such as the tourist gallery windows, 2dF electronics, and unwary astronomers).

Perhaps the most unusual feature of the Dome Air system will be the control of the daytime set point. The intention is to hand control over to the Special Service Unit of the Met. Bureau, whose custom temperature and humidity predictions tailored for the AAT will be automatically fed to the SCADA PC supervising the system's network of Innotech DDC's, who will then fight among themselves over how best to meet their target. To ensure we have the most reliable temperature predictions possible we are currently upgrading our site met. system to provide the Met. Bureau with continuous high quality met. data from Siding Spring.

Once in the dome, the conditioned air will move reasonably briskly (3 ch/h) from the grilles in the main floor throughout the dome, past the telescope and returning via the existing ductwork (j) behind the telescope (m) and outside of the control room (n), to the 3rd floor (k). Separated from the general plenum chamber by new "freezer panel" walls (o), the air will be filtered and returned to the fan coil units.

Although this arrangement will prove satisfactory for temperature maintenance, it will not be adequate for the aggressive cooling of the crane, dome and telescope's massive steelwork desirable in anticipation of a cold front. Complementing the cooling system will be a pair of 1.2 m axial "stirring fans" (p) alt-az mounted 4 m above the dome floor and remotely pointed in almost any direction. Their main task will be to increase the airflow velocity over the steelwork and other areas with high thermal mass. Pointed by a system DDC they will

Although the Dome Air project is the largest component of our seeing program it will not be the end. Following its completion our plan is to revisit cooling of the primary mirror, improve internal ventilation of the telescope structure, and further upgrade ventilation of the hammerhead. The DIMM telescope is being resurrected already, an external DIMM is not forgotten, and the "evil eye" is looking hard at those dreadfully placed electronics racks on the 2dF top end ring. The bottom line is that the days will soon be past where 1.5" seeing at AAT is accepted as the norm, and our observers can look forward to significant improvements in data quality and observing efficiency.

OZPOZ MATED WITH THE VLT

Peter Gillingham

AAO recently delivered its first large-scale instrument for another observatory. OzPoz is a multi-fibre positioner for Unit Telescope 2 of ESO's VLT in Chile. The OzPoz design concepts were based on those of 2dF, but it has a number of novel features. In particular it uses a pneumatically operated gripper with air bearings to give friction-free rotation and high accuracy and has R-theta robot geometry to match the large spherically curved field plates. A description of the instrument can be found in AAO Newsletter 93 (May 2000) and in Gillingham, Miziarski and Klauser, SPIE, Vol 4008, "Optical and IR telescope instrumentation and detectors".

The design and construction contract was awarded in 1998 with preliminary and final design reviews in early and late 1999. The robot positioner for 6dF was built over this period, serving as a prototype for the OzPoz robot. Manufacture of the major OzPoz components began in mid 2000 and the mechanical, electronic, and software elements were sufficiently advanced for the robot to place its first button on a plate in July 2001. Considerable further development was needed to prepare for the first stage of the pre-ship review in October. A second stage, mainly for software, followed in December, with a successful outcome, including the first integration of the OzPoz control software with FLAMES OS, which oversees control of the two spectrographs, GIRAFFE and UVES, as well as OzPoz.

Finally OzPoz was ready to ship on February 6 this year. Moving a couple of tonnes of delicate instrumentation to a mountain in the Atacama desert is no easy task; one of the first tests was to confirm that the main crate, which Stan Miziarski had designed to fit neatly in an aircraft hold, would squeeze through the door of the Epping OzPoz lab. The Back Page shows Chris Evans, the project manager, helping OzPoz stay on schedule and on the fork lift. An OzPoz "family photo" (see the OzPoz Scrapbook, pp32-33) is a reminder of how many AAO staff had contributed to the project.

The five crates' journey by road and air was completed before the initial AAO crew (Dan Popovic, Gordon Schafer, Lew Waller and I) arrived on Cerro Paranal on February 26 to open the crates and begin re-assembly. After settling into the swish new Residencia, we were able to start unpacking and moving the equipment into the Auxiliary Telescope Hall (ATH) for its re-assembly and testing. Thankfully, the instrument arrived mostly intact, the only significant damage being inside the electronics enclosure where the support bracket for two vacuum pumps had cracked and spread fine aluminium and aluminium oxide powder around. Lew had to remove all the chassis and clean their interiors before it was safe to power up. I felt suitably guilty, having persuaded Lew that shipping the electronics fully assembled into the enclosure would save time on Paranal.

Very useful features of the ATH were an overhead crane and a pit, over which we positioned the Exchanger. Then the bundle of cables descending from the robot rotation axis was hung into the pit, allowing the bundle to twist freely. To carry fibres and cables away from the top of the Exchanger, we strung ropes from side to side of the ATH; these were also useful for drying washing. While it had been a tight fit in the Epping lab, OzPoz was dwarfed, standing alone in the 25 x 11 x 15 m high ATH. The instrument enclosure, the "shed", was re-erected over a few days in parallel with other work. After a mild earthquake one night – too weak to wake any of us – we roped the electronics enclosure firmly to some handrails and braced the Exchanger against sliding. The first configuration (of 9 buttons) was achieved on March 4, and with a sense of relief the AAO entourage accompanied Jason Spyromilio on a tour of UT2, including its nether regions, the interferometer delay lines and beam combining room. That night, we hosted a group of astronomers to a demonstration of OzPoz. Feedback was very positive – there was a feeling abroad that OzPoz is much more fun than other VLT instruments.

The first OzPoz component to be set on the Nasmyth Platform (for a trial fitting) was the enclosure. Negotiating the goods entrance to the UT2 building was tricky; we'd changed from a truck to a very low trailer but still almost had to resort to deflating the trailer tyres to gain access. Then it was a near thing lifting the enclosure off the trailer and raising it through the trap-door into the dome. Subsequently we found this part of the transfer was much easier with the enclosure turned 90 degrees in azimuth. On March 6, while extensive preparations were under way for the visit of the German Foreign Minister, we were treated to a tour of the Paranal dump. Interestingly, one travels about 6 km towards Antofagasta, then heads off for a few km into the hills to a dry dusty valley, where there are all manner of discarded objects. We searched successfully for steel from which Gordon could fabricate brackets to support the electronics cubicle in an earthquake-resistant manner on the Nasmyth platform. The other big advance that day was getting permission for Gordon to use the (small but well-equipped) workshop just across from the Auxiliary Telescope Hall whenever necessary.

Holes were drilled, cables ducted, and brackets painted. The ESO Technical CCD was giving sporadic problems as it had in Epping and as, we now found, was to be expected from Paranal experience with TCCDs. We acquired a theodolite that could be used to align OzPoz on the platform – it was spotted on a shelf by snooping in the main store while three stores staff were trying to find staples of the right size to fit the stapler we inherited in the ATH office. The same expedition yielded a spring folder twice as thick as I wanted, four sheets of abrasive paper coarser than we needed and not waterproof, and no string.

However, string or no string, work continued apace, broken only by a welcome three nights off the mountain – one in Antofagasta and two in San Pedro d'Atacama in the far inland , which was relatively moist that week. Tony Farrell, Rolf Muller, Roberto de Propris, and Will Saunders joined us soon after our return and wholesale fitting of retractors began. Hundreds of improved (Mk2) retractors had been assembled in Epping under Stan's direction after the main OzPoz shipment left and they'd reached Paranal in two batches by this time. On March 19th we reached an important milestone with the successful completion of a few configurations with about 120 Medusa buttons. The enclosure was fitted on the platform for a second trial, engaged with newly fitted rails that had been aligned straight and parallel, then removed. The discovery that the Nasmyth platform is higher in relation to the Nasmyth axis than nominal by about 8 mm gave us pause for serious thought about how to accommodate this. Return of the exchanger and robot to Epping was considered only briefly! In fact, there was no trouble in lowering the exchanger – packing blocks were big enough to allow for this – but we had to cut metal off the support base for the robot.

On March 20, OzPoz was stripped down for transfer to the telescope, and on the 21st the robot and exchanger were put in place on Nasmyth platform A of Kueyen (the official name, meaning the Moon, for VLT UT2). This was the first time that we'd seen the assembly sitting with the rails right at floor level. On rolling the Exchanger towards the corrector lens to make the first engagement of a plate with the pillars newly installed on the corrector support cross, we made the disquieting discovery that the wire guides on the retractor mouths would contact the bezel on the corrector a few mm before the locators fully engaged the balls on the pillars. Much discussion ensued – but the problem was fairly easily fixed by adding spacers between the pillars and the corrector, as was necessary to achieve the nominal lens to field plate spacing, in any case. The list of jobs to do was shrinking, and we began thinking first light was only a few days off.

We still had a week to wait, however. Adding the spacers required that the robot be mounted further back from the telescope than we'd expected, and this meant that the hole in the Nasmyth platform for the theta axis, which the ESO staff had cut out the previous week (through 60 mm thick steel) was now misplaced by 25 mm. Out of the frying pan and into the fire! But a check on the optical consequences of running with a slightly smaller back focus showed that we could get away with it, moving the robot as far as we could, which left the back focus ~ 15 mm less than the design value, still with plenty of clearance between the corrector cell and the retractors.

VLT software tests and high winds each produced delays, and a misunderstanding in the software handling of limit switches led to our giving up hopes of first light on the night of March 26. The following morning it was found that the bracket holding the four proximity switches controlling the tumble drive was broken. A more robust replacement was designed, manufactured and installed that evening. A problem in excessive servo following errors was traced to a misalignment of the theta encoder read head. After readjusting the read head, the evening ended with the first movement of buttons by OzPoz while on the VLT, but without pointing at the sky.

It had been a long, tortuous road, but on the night of Thursday March 28 we finally made it onto the sky on a beautiful, calm night with a full moon. After a few more minor delays, most significantly getting adequate back illumination onto all four FACB bundles fitted to plate 2, Kueyen shutters were opened and observations began using OzPoz. Our modest aim before opening Luca Pasquini's champagne was to acquire stars into four fibre guide bundles simultaneously, and this was achieved at around 3 am. OzPoz looked impressive configuring in the dark (or as dark as it gets in the enclosure with a full moon high above) with the red LED indicators on the end of the R arm whizzing around.

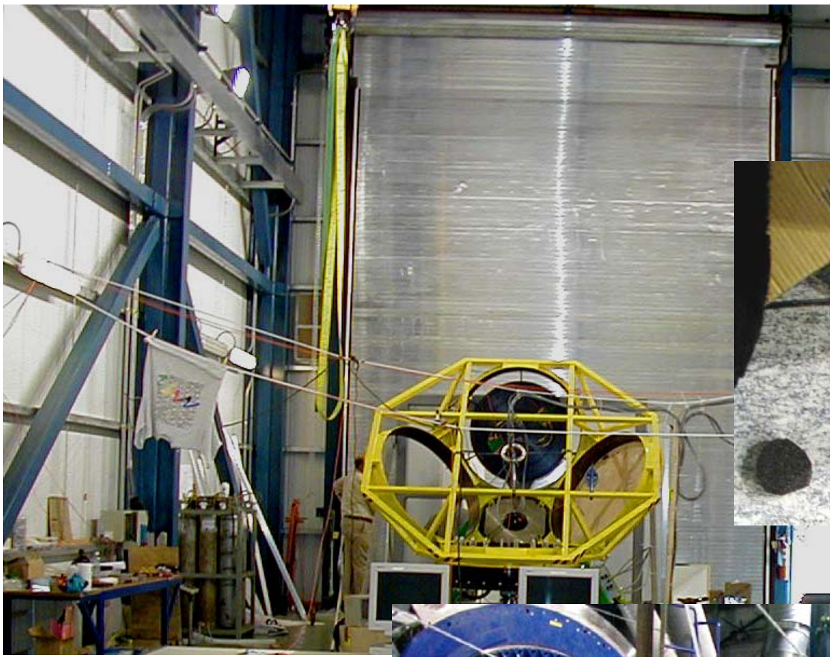
We had a serious setback next evening (on Good Friday) when we found that the OzPoz robot had serious problems coping with lower temperatures than we'd experienced at Epping or in the ATH. The theta drive developed high friction and the theta encoder tape bulged a little, making it impossible to set the read head correctly. And the temperature was only 12 deg – still well short of the lowest temperature in the spec. ! On Saturday we confirmed that heating removed the problem, and for that night – the last for this round of commissioning – we set up a couple of fan heaters on low to keep the robot cosily warm. Measurements of the robot scale with respect to the sky, begun two nights earlier, were refined, and we obtained the first fibre-fed stellar spectra from UVES.

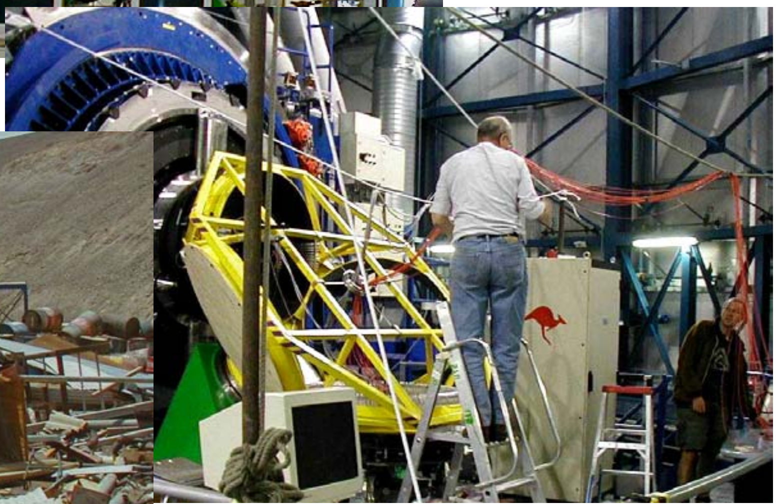
After coiling all the fibres onto the rear of the exchanger, so as to make room for the installation of the

The OzPoz Scrapbook

spectrograph Giraffe onto the rear of the Nasmyth platform, and hastily clearing tools and other material from the Nasmyth area, we left Paranal early on Easter Sunday afternoon. Although satisfaction with our progress was spoilt a little by the late discovery of the robot's low temperature problems, we left pleased that OzPoz had demonstrated its capabilities in most major respects and confident that it would perform as needed when connected to Giraffe.

What had been intended as the second commissioning run, Comm2, starting in late April, was cancelled by ESO due to the pressure on Paranal staff of other activities at that time. Now Comm2 nights are to start June 20, when OzPoz will be linked to Giraffe. In advance of that run, we will make modifications and tests to ensure OzPoz operates properly over the full range of temperatures.





LETTER FROM COONABARABRAN

Rhonda Martin

1 April 1977 saw the very first AAO Newsletter. It was the time when Don Morton was Director of a brand-spanking-new state-of-the-art telescope and passenger aircraft flew into Coonabarabran airport – remember that? ('Aeroplane – a heavier-than-air flying machine having one or more wings and driven by a motor', see figure. This is for the benefit of Site people who rarely get to see such a marvellous object.)

One hundred issues later and although very much still state-of-the-art the telescope is no longer brand-spanking-new but of mature age and experience and under the Directorship of Brian Boyle. Across the way, the UK Schmidt telescope is in much the same boat. Together, these telescopes form a splendid team. From IPCS through bevies of instrumentation to 2dF and IRIS2 on the AAT, to 6dF on the UKST, we are still in the forefront of astronomy. IPCS is now in a museum and its makers could perhaps only dream of something as sophisticated as 2dF.

If instrumentation has changed, people have changed even more. We tend to laugh now at the images of a young Bob Dean (a mere child!) in white shirt and tie and from the pictures we see they even wore suits, a far cry from the more practical jeans and T-shirts of today. Gordon Schafer even had hair, but then, didn't they all! It was even a different colour but I am sure that is just colour changes in old photographs, Mmmmm?

In an increasingly technical world it is good to see that our people keep their sense of humour. This is a fun place to work and it hasn't taken long for our new Instrument Scientist, Martin Oestreich, to discover the fact. Martin, like Shaun James, was formerly with ATNF at Narrabri and along with his partner Annie, and their new baby, Christopher, is now ensconced on the mountain. Many, many welcomes.

The late and much-lamented Sydney-Coonabarabran air service.

I guess by the time of the two hundredth issue, we will have advanced so much that all staff will be wearing carbon fibre body suits and will only have to think a command for a machine to spring into action. The kangaroos lying in wait for Frank Freeman on his way home after night shift will wait in vain; who will need cars when teleportation will be all the go? We look forward to it all.

EPPING EVENTS

Ray Stathakis

There have been a number of comings and goings. We welcome Quentin Parker back to the fold. Quentin worked as a staff astronomer at the UKST for many years before returning to Edinburgh. He has taken up the position of AAO/Macquarie Lecturer, and we have already seen enhanced communication between AAO and the nearby University of Macquarie, with a series of combined talks. We also welcome David Correll who joins us from the Australian Antarctic Division. David will be working on the AAΩ project as an electrical/electronics engineer.

Lucyna Kedziora-Chudczer has left us to take up a position at UNSW — we wish her well. We will also be sorry to bid farewell to Geraint Lewis at the end of August as he takes up a Lectureship at Sydney University. At least both are still nearby — stay in touch, guys.

Congratulations to Gabriella Frost on the birth in April of daughter Daniella Julia. Daniella has been a welcome visitor on occasion, and Gabriella has just returned to work as this newsletter goes to press. Garry Kitley, formerly at the AAT, will be undertaking Katrina Sealey's role in the Systems group for the next nine months while Katrina is on maternity leave, following an hourly-expected event. All the best, Katrina!

In April, staff attended a solemn cake-cutting ceremony to mark the end of the 2dF galaxy and quasar surveys, and June saw the invasion of the media and a subsequent (unrecognisable) photo of Chris Tinney on the front page of the Sydney Morning Herald. Something about a planet... A series of lunchtime talks on instrumentation have proven extremely popular. The departure of the OzPoz crew to Chile produced an unnatural quiet at morning tea, offset by the building work being carried out to remodel (re-re-re-model?) the technical areas.

We are pleased to welcome four vacation students: Jackie Marcel who is working with Roger on instrumentation; Vida Odoi who is working with Anna and Andrew; Edward Cackett who is working with Joss; and Ryan Houghton who is working with Scott and Brian.

LIBRARY NEWS

Sandra Ricketts

In issue 50 of the AAO Newsletter my predecessor, Robyn Shobbrook, reflected on the first 14 years of the AAO library. Now another 13 years have passed and we have reached issue 100. In those first 14 years the library moved around numerous times until it finally reached the first floor of the Massey building almost 20 years ago. It hasn't moved since, but many other changes have taken place.

In those days the collection was recorded on a card catalogue (remember those?) with some files such as the scientific papers on the venerable VAX. The catalogue was finally transferred to computer by the beginning of 1989. 1989 also saw the acquisition of a PC for the telescope library, while in 1993 the Epping library got a new PC with a whopping 200Mb hard drive! The library has just recently upgraded to a machine with a hard drive of 18.6Gb. Times change. (The librarian's cast-off PC has now been placed on one of the desks next to the plan cabinet for general use)

Since issue 50 the library has continued to evolve and develop. The same (upgraded) software is used to catalogue the collection, but it is now searchable from the library's web page. Vastly more user-friendly!

1993 also saw the distribution of the Astronomy Thesaurus, which had occupied the attention of a number of astronomy librarians for some years. Robyn, together with her husband Bob, was the main author and the driving force behind its production.

For the first 20 years of the AAO library there had only been one librarian, but at the end of 1995 Robyn decided to retire and I came to the library at the start of 1996. The physical library is still much the same as it was then, with minor changes, but the electronic aspects have greatly increased. The library web page is an important aspect of the library which could now be regarded more as an information centre. The catalogue is now on-line as are the major astronomical journals. In fact these are now only available in electronic format at the telescope library, which has its own PC with web access. Whether this should be the case at Epping as well is at present being considered. The page of AAO eprints is maintained by the librarian, and hard copies of these are no longer mailed out with the newsletter. Instead, a list of abstracts is issued to those institutions which used to receive preprints. A list of observatory publications from the Radcliffe collection has just been placed on the web page, and can be seen at http://www.aao.gov.au/AAO/library/obspubs.html

And it hasn't just been a library! In 1999 it doubled as an optical fibre laboratory, while David Lee carried out the initial construction of SPIRAL. At the moment it is again fulfilling this dual role, this time for the building of a prototype for AAΩ.

ANSWERS TO TEST

1. Cicadas 2. London Bridge 3. Sheep 4. Trapping rabbits or touring pubs 5. In twilight 6. A rumour (originally World War I water tank) 7. Tektites 8. Offa's Dyke separates Wales and England 9. Flow 10. Dimwit 11. Formerly a penny, threepence, sixpence 12. No – it means rubbish 13. Families of children in Arthur Ransome's books 14. Shearer 15. Penniless 16. To speak in Liverpool (UK) 17. The radio series "The Archers" 18. Salvation Jane, a purple wildflower/weed 19. Glumly or comely 20. The English Channel tunnel 21. Canal 22. NSW bushranger 23. Old land divisions according to population 24. Former religious holiday five weeks after Easter 25. Childrens book by Norman Lindsay 26. Almost no chance at all 27. Snugglepot 28. East Anglian native marshland

To score, make N1 the total of correct answers to questions 1,3,4,6,7,10,11,14,15,18,22,25,26,27 and N2 the total correct answers to the other questions. Now compute (N1-N2)/(N1+N2). A score of +1.0 shows you to be steeped in Australian culture, -1.0 to be thoroughly British; scores near zero identify the true Anglo-Aussies.

THE BACK PAGE

Chris Evans, Project Manager:

keeping OzPoz on time, on budget, and on the fork lift

We bid farewell to OzPoz in February, as it began its journey to the VLT. Inside see a description of the first commissioning run at Paranal (pp 30 – 33). We thank the anonymous author for the title of this photo. Any further suggestions for titles would be received by the editors with interest.

editor RAY STATHAKIS editorial assistant SANDRA RICKETTS

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