NUMBER 95 NOVEMBER 2000

AAO NEWSLETTER

ANGLO-AUSTRALIAN OBSERVATORY

2dFGRS is past halfway...

... and has determined the total mass density of the universe.

The 2dF Galaxy Redshift Survey recently passed the halfway mark on the way towards mapping 250,000 galaxies. Already, the survey has been used to measure the way galaxies cluster in the universe with unprecedented accuracy. Analysis of these data show that we live in a low–density universe. See the article on page 5 for details.

contents

3	Probing extrasolar planets with gravitational microlensing (Geraint Lewis et al.)
4	SPIRAL observations of the radio galaxy PKS B1733-56 (Julia Bryant)
5	2dF Galaxy Redshift Survey passes halfway mark (Matthew Colless et al.)
6	The detection of variable interstellar absorption lines with the UHRF (Ian Crawford & Richard Price)
8	Politics and personalities in Australian astronomy: the Russell – Tebbutt feud (Wayne Orchiston)
12	Observatory news
18	Local news

DIRECTOR'S MESSAGE

The cover of this Newsletter celebrates the 2dF galaxy redshift survey passing the half-way mark to its goal of 250000 redshifts. In the September run alone, the 2dFGRS obtained more redshifts than the entire Las Campanas redshift survey, the previous largest galaxy redshift survey. Over the next few months we can look forward to the first major results emerging from both the galaxy and QSO redshift surveys. One such result is reported in the accompanying Newsletter article by Matthew Colless and the 2dFGRS.

Within the next few months, the community will also have access to much of this data, as the survey teams are obliged to release catalogues comprising 100000 galaxies/10000 QSOs by June 30, 2001. This will be followed up by release of the final catalogue within 12 months of survey completion. Both teams are committed to providing data releases (including positions, redshifts and spectra) which will enable the community to exploit the surveys in full.

It is also very encouraging to see the first scientific results emerging from SPIRAL, the AAO's integral field spectrograph (see the article by Julia Bryant). Integral field spectroscopy is likely to have a central role in the AAO's future instrumentation suite, as the AAO seeks to provide a next-generation spectroscopic facility in the shape of the AAOmega. AAOmega is the proposal to equip 2dF with new spectrographs, larger detectors and a new wide-field integral field unit. At their last meeting, the AATB gave the go-ahead for the AAO to embark on a concept design study for AAOmega that should be completed by September 2001. A crucial first step in the concept design phase is the construction of the user requirements document. Responses from the community to a draft version of this document are now being collated and a revised version should be issued during December. On-sky tests of sky-subtraction, spectrophotometry and polarimetry are also planned during the next few months as further input to the design study.

On a more disappointing note, it is now clear that we will fail in our goal to commission IRIS2 by the end of the year. Commissioning has now slipped by 3-4 months into the first half of semester 00A. Given the high numbers of IRIS2 proposals that we have already received, it is clear that this will come as frustrating news to the many people who wished to use it. The AAO and the IRIS2 team in particular are keenly aware of IRIS2's scientific timeliness and thus the need to provide a commissioned instrument as quickly as possible.

The ability to deliver instrument projects on time is, of course, central to the success of the AAO's future strategy. While the AAO has had many successes over the past year (SPIRAL, SOAR IFU, WFI) and is still on-track in other active projects (6dF, OzPoz, Echidna), it is also important that we learn the lessons from projects like IRIS2 that have not progressed according to the plan.

Brian Boyle

Next Issue:

If you have some recent results based on AAT or UKST data, or other items of interest, please send articles to newsletter@aaoepp.aao.gov.au by January 22, 2001. Article length can vary from 2 paragraphs to 2 pages, with preference for plain or latex text and gif or postscript figures.

Picture credits for the front cover: Antique letter scales, from the collection of Matthias Hass, Germany, http://www.scales-and-weights.com/. Still from "2dF the Movie", created by the 2dFGRS team, AAO and the Centre for Astrophysics and Supercomputing at Swinburne University, http://www.swin.edu.au/astronomy/2dfmovie/.

PROBING EXTRASOLAR PLANETS WITH GRAVITATIONAL MICROLENSING

Geraint Lewis (AAO), Rodrigo Ibata (Strasbourg) & Ceri Ashton (Cardiff)

At least fifty extrasolar planets have now been identified (see www.exoplanets.org). However, searching for these planets relies on the detection of planetary transits or Doppler signatures and is limited to nearby stars, within several tens of parsecs of the Sun. Planets at much greater distances can be found by searching for signs of planets perturbing the gravitational lensing properties of their host star. Given the strongly non–linear interaction between lensing bodies, the relatively small mass of a planet can result in a short–term, extreme flaring in brightness, in addition to the magnification of the host star (Wambsganss1997). **It has been suggested that some of the known microlensing events already display planet–induced features** (e.g.Bennett et al.1999).

An alternative approach is to use microlensing as Zwicky's "Natural Telescope" to search for planets orbiting stars which are typical sources of microlensing events — in the Galactic Bulge and Magellanic Clouds. Such an approach was recently investigated by Graff & Gaudi (2000) and Lewis & Ibata (2000). By considering 'hot Jupiter' planets orbiting close to their host stars they demonstrated that the feeble light reflected by the planet (only 2×10^{-4} the light of their host star), can be substantially magnified during a microlensing event. For instance, a planet in the Galactic Bulge would be magnified by a factor of ~160. The presence of a planet would show up as small deviations from a smooth light curve, of the order of several percent, which could be readily detected with a 10-m telescope. In conjunction with detailed monitoring programs, **these signatures can be used to search for planets through microlensing events.**

While various techniques allow us to locate extrasolar planets, they do not directly measure their physical properties. In recent work Seager, Whitney & Sasselov (2000) took a closer look at the light reflected from an extrasolar planet. By investigating a range of planetary models, they found that the physical conditions in the atmosphere dictated the species and properties of the condensed matter. These particles in the atmosphere leave a distinctive signature by polarizing a small proportion of the light reflected from the planet. However, the proportion of polarized light is so small (at a level of 10^{-6}) it is swamped by the light of the host star, and remains well below current detection limits. Considering this model further, Lewis & Ibata (2000) showed that this polarization is also boosted during a microlensing event, increasing from less than 10^{-6}, to a substantial fraction of a percent. In such sources, polarization at this level is readily detectable by 10-m class telescopes, **providing us with the exciting possibility of probing the composition of planetary atmospheres at kiloparsec distances, something that is currently not possible for planets in our own backyard.**

It is well known that the details of a microlensing event depend not only on the characteristics of the lensing object, but also on the form of the source being lensed. As a distant planet orbits a star it will display phases, similar to our own inferior planets. Ceri Ashton, while a UK Student Fellow at the AAO, investigated the influence of planetary phase on the resulting microlensing signature. She found that the degree of microlensing–induced magnification is strongly dependent upon the light distribution reflected from the planet, with more crescent–like sources undergoing greater magnification (Ashton & Lewis 2000). The shape of the microlensing light curve is also strongly dependent upon the planetary phase. One configuration produces gentle variations of the lightcurve, while another produces rapidly–changing, asymmetrical features. Of course, the fraction of reflected light is also a function of the planetary phase, and while very crescent–like profiles undergo the strongest magnifications, observations of the resultant variations (<0.5%) would only be possible for 30-m class telescopes. The less extreme configurations are, however, within the reach of today's 10-m telescopes, and the determination of planetary phase is important in untangling the clues to the composition of the planetary atmosphere obtained from polarization variability. As the polarization characteristics of the light reflected from the planet are also dependent upon planetary phase, this study is being extended to understand the microlensing signature in polarized flux, and examine whether it can reveal further clues to the composition of extrasolar planets.

While gravitational lensing only provides a rare fleeting glimpse of planetary companions in the Galactic Bulge or the Magellanic Clouds, its magnification can provide not only clues to the existence of extrasolar planets, but also their atmospheric composition. Such observations would clearly demonstrate how Nature's Telescope can provide a more detailed view of the Universe than any offered by today's technology.

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SPIRAL OBSERVATIONS OF THE RADIO GALAXY PKS B1733–56

Julia Bryant (University of Sydney)

The hosts of powerful double–lobed radio galaxies are typically giant elliptical galaxies. The orientation and axes dimensions of the ellipsoid can be modelled from the radio axis position angle and the rotation axis of the stars and gas. It is not uncommon in elliptical hosts for gas and/or stars to be rotating about an axis perpendicular to the radio axis and decoupled from each other (Bryant & Hunstead 2000). This is thought to be due to the introduction of gas from a merger or interaction with a gas-rich galaxy. Apart from decoupled stellar and gas dynamics, many elliptical galaxies with radio jets show evidence of mergers through dust lanes, extended emission-line gas and extra-nuclear starburst regions. The extent of the gas in some cases is too large to be photoionised by the nuclear source, and instead may be ionised by shocks along the radio jet or by the starburst regions.

SPIRAL is an ideal instrument to investigate the dynamics, interactions and morphology of elliptical host galaxies for the following reasons: (a) Emission line images trace the extent of the ionised gas. Alignment of this gas with the radio axis may identify shocks as the excitation mechanism, or alternatively a coincidence with starburst regions may point to the gas being photoionised. (b) The gas and stellar dynamics can be mapped across the galaxy from the emission and absorption lines respectively. This may identify both disrupted dynamics due to a current merger, or decoupling of the gas as in triaxial systems. It is not possible to accurately measure the rotation axes from long slit spectroscopy alone; an IFU image is required. (c) The ratio of emission line images can identify AGN and starburst processes, defining the extent of the nuclear AGN and the distribution of extra-nuclear starbursts. (d) A colour image formed from the ratio of red and blue continuum light may show direct evidence of a current merger between two galaxies of different colours.

MRC B1733–565 (= PKS 1733–56) is a double–lobed, edge–brightened (FR II) radio galaxy with a 17 mag E0 host. The redshift of 0.0985 was measured from an optical spectrum taken with the IPCS at the AAT in 1981 (Hunstead et al. 1982). The spectrum shows strong [OIII]$\lambda\lambda$4959, 5007 and Hβ emission lines, together with an underlying stellar continuum, making the galaxy an excellent target for SPIRAL.

During the SPIRAL commissioning run in March 2000 (Lee 2000), 1733–565 was observed in 0.7" seeing. The total exposure time was 90 minutes. With the 316R grating the wavelength coverage was from 5260 — 6603 Å. The 22" x 11" field covered most of the elliptical galaxy, with 0.7"/pixel. Reduction was done with the automatic data reduction software adapted from 2dfdr. While this was effective, some of the fibres were missed in the fitting process; this explains the blank pixels in the figures discussed below. Sky subtraction used pixels from the north-east and south-west of the image in order to avoid galaxy emission. Since the ionised gas was later found to extend well beyond the broadband optical image, sky subtraction may have been more effective with a separate sky frame offset from the galaxy.

The continuum subtracted [OIII]λ5007 emission line image in Figure 1 reveals that ionised gas extends to >29 kpc (>12", H_0=50 km s^{-1} Mpc^{-1}) at a P.A. of 130 ± 5°. In particular, a tail of gas to the south-east is not apparent on the continuum image in Figure 2. Furthermore, the P.A. of the gas is perpendicular to the radio axis which sits at 38 ± 1°. This excludes shocks along the radio jet as the excitation source of the emission line gas.

Velocities were measured from the [OIII]λ5007 line and the resultant rotation image is shown in Figure 3. The pixels shown had sufficient S/N to measure the line without binning. Gas velocities were measured to be up to ~ ±200 km s^{-1} with a rotation axis at a P.A. of 43 ± 7°.

Figure 1. [OIII]λ5007 emission line image. North is to the right and east at the bottom. The image is 22" x 11".

Figure 2. Continuum image of the same size and orientation as Figure 1. The two objects to the north-west and south-west of the galaxy are both stars.

Figure 3. Velocity image made from the [OIII]λ5007 emission line. The lightest pixels represent a receding velocity of ~ 200 km s^{-1} while the darkest grey pixels mark approaching velocities of the same magnitude. Regions in which the emission line could not be measured in a single spectrum are filled by black pixels. The field size is 9.8" x 9.8" centred on the nucleus. The line marks the radio axis P.A. of 38°.

Therefore the gas has a uniform rotation about the radio axis leaving no evidence of disruption due to mergers/ interactions. The continuum image shows no evidence of a dust lane which would be another indication of a recent merger. An initial look at the Mg-I absorption line indicates that the stellar rotation is about the same axis as that of the gas. The absorption lines are fainter than the emission lines and were only measurable in binned spectra. A longer integration time would be required to effectively map the stellar rotation.

The ratio of [OIII]λ5007/Hβ indicates AGN activity at the nucleus, as expected, and a possible region of starburst activity coincident with the extended gas to the south-east.

These preliminary observations have shown that measuring gas dynamics, starburst distributions and excitation mechanisms with SPIRAL is simple in elliptical hosts such as 1733–565. In elliptical hosts with known merger activity and disrupted dynamics SPIRAL would be very effective in deciphering the dynamics and excitation processes, which are otherwise difficult to model from long slit spectroscopy.

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Figure 1 (right). A false–colour representation of the redshift space correlation function for the 2dFGRS, $\xi(\sigma,\pi)$, as a function of transverse (σ) and radial (π) pair separation. It is elongated in the radial direction at small transverse separations, and compressed in the radial direction at larger transverse separations. The contours belong to the best–fitting model, and have distortion parameter β = 0.4 and small–scale pairwise dispersion σ_p = 4 h^{-1} Mpc.

2DF GALAXY REDSHIFT SURVEY PASSES HALFWAY MARK

Matthew Colless and the 2dFGRS team

The 2dF Galaxy Redshift Survey passed the halfway mark during September, and is on schedule for completion at the end of 2001. With 130,000 redshifts measured to the beginning of October, some of the major cosmological results are beginning to emerge, in preliminary form, from the large scale structure of the galaxy distribution. The first of these results is the most precise measurement to date of the total mass density of the universe. This is obtained by modelling the distortions, in redshift space, of the galaxy correlation function — because galaxy redshifts are the combination of the Hubble expansion and their peculiar velocities, the clustering of galaxies in redshift space is distorted in redshift space.

Figure 1 shows the galaxy correlation function computed from the 2dFGRS as a function of separation in the plane of the sky and along the line of sight. At small separations on the sky, the correlation function is extended along the line of sight — this is the familiar Finger of God effect produced by the large relative velocities of the galaxies in groups and clusters. At larger angular separations on the sky, galaxies are on average falling towards each other due to their mutual gravitational attraction. This distorts the correlation function by compressing it along the line of sight, and allows a statistical measure of the β parameter, combining the total mass density of the universe Ω and the bias parameter *b*. Peacock et al. (2000, Nature, submitted) model these effects and derive a value β (= Ω/b) = 0.39 ± 0.05. Allowing for the effective redshift and luminosity of the 2dFGRS sample, this result is in good accord with recent CMB anisotropy results, and favours a low–density universe with Ω ~ 0.35.

THE DETECTION OF VARIABLE INTERSTELLAR ABSORPTION LINES WITH THE UHRF

Ian Crawford & Richard Price (UCL)

Interstellar absorption lines are formed when light from a distant star passes through a foreground interstellar cloud. Documented cases of *variable* interstellar absorption lines are quite rare, and until recently all reported cases were in highly disturbed regions of the interstellar medium. For example, the first reported case was a variable interstellar Ca II K line towards HD 72127 (Hobbs et al. 1982), which lies behind the Vela supernova remnant (SNR). Using the UHRF, Blades et al. (1997) found evidence for a variable interstellar Na I D line towards HD 28497, which lies behind the Orion–Eridanus superbubble, and very recently, Danks et al. (2000) have reported variations of UV interstellar lines in the Carina Nebula from HST–STIS observations.

Recently, we have discovered two more examples of variable interstellar lines using the UHRF. Firstly, we have found clear evidence for a variable interstellar Na I D component towards δ Ori (the most westerly star in Orion's belt) by comparing a 1994 UHRF spectrum with spectra obtained in 1999 and 2000 (Price et al. 2000a,b). Variability is clearly apparent in a comparison of the recent UHRF data with published data going back to 1966, and also between the 1999 and 2000 UHRF spectra. Figure 1 shows the decrease in the strength of the Na I D_1 component at +21 km/s (heliocentric) between 1994 and 2000. The fact that the strengths of the other absorption components present towards this star have not changed, greatly strengthens the interpretation that this change results from a real decrease in neutral sodium column density in this component over a six–year period. Interestingly, like HD 28497, δ Ori also lies behind the Orion–Eridanus shell, and the observed variability is perhaps most plausibly assigned to structures associated with it. Note that the line is very narrow, the doublet structure in the line is the Na hyper-fine splitting (separation 1.08 km/s), and the line velocity dispersion (*b*–value is 0.50 ± 0.05 km/s) implies a rigorous upper–limit to the kinetic temperature of the absorbing gas of 350 Kelvin.

The UHRF is one of only very few astronomical spectrographs in the world able to reliably determine the widths of such narrow lines. More recently, we have found variable interstellar Na I D and K I lines towards the bright star κ Velorum, by comparing UHRF spectra obtained in 2000 with earlier observations with the same

Figure 1. Comparison of the interstellar Na I D_1 spectra of δ Ori obtained with the UHRF in 1994 and 2000. Note that over this period the strength of the absorption component at a heliocentric radial velocity of +21 km/s has decreased significantly. Tick marks indicate the positions of all the interstellar velocity components identified towards these stars, and Earth–symbols indicate the locations of atmospheric water lines.

Figure 2. Comparison of the interstellar K I spectra of κ Vel obtained with the UHRF in 1994 and 2000. Note that the strength of this line has increased by about 40% over this period.

instrument in 1994 (Crawford et al. 2000). Figure 2 compares the K I (λ7699) lines obtained in 1994 and 2000. The equivalent width has increased by 40% over this period; a smaller (16%) increase was also observed for the more heavily saturated Na I D_1 lines over the same period. Extensive checks (including re-extraction and reduction of the 1994 data, and multiple observations in 2000) have convinced us that this also is a real change in interstellar line strength over this six–year period. This line is also very narrow (b ~ 0.6 km/s), and there is some evidence, discussed by Crawford et al. (2000) that it is actually a blend of two even narrower components, only one of which has actually varied in strength.

Interestingly, while κ Vel is in Vela, it lies well to the fore of the supernova remnant (350 parsecs for the SNR *versus* 165 parsecs for κ Vel), and is in any case off-set by 13 degrees on the sky (compared with a SNR diameter of about 5 degrees). Therefore this variable component does *not* arise in the Vela SNR. Indeed, it seems most likely to arise in fairly quiescent outlying gas associated with a well–defined 'ridge' of molecular clouds which lie in this direction in the distance range ~ 170 — 200 pc (Dame et al. 1987, Dunkin & Crawford 1999). In this respect it is interesting that Heiles (1997) has recently proposed that thin interstellar sheets or filaments (only tens to hundreds of AU thick) are ubiquitous in such interstellar clouds, and we interpret this variable component to result from the line of sight to κ Vel gradually entering such a structure (see Crawford et al. 2000 for more details).

Acknowledgements

We would like to thank all those at the AAT who have supported the UHRF over the years. Regarding the present work, the variable lines towards κ Vel were discovered during UHRF throughput checks in early 2000, and special thanks are due to all those who performed these checks, identified the reason for reduced UHRF throughput (which had become serious by late 1999), and with skill and dedication corrected the problem and got the UHRF efficiency back to its nominal value.

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POLITICS AND PERSONALITIES IN AUSTRALIAN ASTRONOMY: THE RUSSELL – TEBBUTT FEUD

Wayne Orchiston (AAO)

The second half of the nineteenth century is an interesting period for those of us who research the history of astronomy. For Australian astronomy it was a "golden age", with the establishment of professional observatories, substantial growth of popular interest in astronomy, the establishment of a network of significant private observatories across the nation, and formation of the earliest astronomical groups and societies (Haynes, Haynes, Malin and McGee 1996).

During this period, when much of the research effort worldwide was still directed towards positional and descriptive astronomy, amateur astronomers were able to make a significant contribution. In Australia, there was little difference between the professional astronomers and the serious amateurs. They had similar intellectual, mathematical and analytical skills; joined the same scientific societies (both in Australia and overseas); served on the same committees; vied for the same prizes and awards; possessed instruments of similar size and precision (the Great Melbourne Telescope excepted), carried out similar research (until the advent of the Carte du Ciel Project); and published in the same local and international journals.

Amiable amateur-professional relations were a feature of international astronomy during the nineteenth century, and it was possible for talented amateurs to make the transition to professional ranks. Tension between vocational and avocational astronomers only began to appear towards the end of the century with the emergence of the so-called "New Astronomy", astrophysics.

In Australia, the only conspicuous breakdown in peaceful amateur-professional relations occurred in Sydney when the Government Astronomer of New South Wales, Henry Russell (Figure 1) and John Tebbutt (Figure 2), an amateur astronomer from nearby Windsor, began to vie for supremacy (see Orchiston 2001).

Henry Chamberlain Russell (1836-1907) joined the staff of the Sydney Observatory (Figure 3) in 1858, becoming Director and Government Astronomer in 1870. During his tenure, he acquired a 29.2cm refractor and a 33cm astrograph for the Observatory, made important observations of the 1874 transit of Venus and a significant contribution to double star astronomy, and was an Australian pioneer in the application of photography to astronomy. He also observed comets, eclipses, Jovian atmospheric features, and transits of Mercury. Russell invented a number of meteorological instruments and also experimented with aspects of telescope design. He was a leading figure in the Royal Society of New South Wales (chairing the short-lived Astronomy Section), and founded the Australasian Association for the Advancement of Science. In addition to its time-keeping functions and astronomical research, the Observatory was involved in meteorology, seismology and tidal studies during Russell's directorship, and also provided a public information service. In recognition of his contribution to Australian science, Russell was elected a Fellow of the Royal Society (Bhathal 1991; Orchiston 1988b; Wood 1958).

John Tebbutt (1834-1916) was a wealthy farmer who established the Windsor Observatory in 1862 and gradually built up the facilities (Figure 4) and the

Figure 1: Henry Russell (Courtesy: Sydney Observatory)

Figure 2: John Tebbutt and the $100 bank note (Orchiston Collection)

instrumentation, culminating in the acquisition of a 20.3cm Grubb refractor in 1886. In addition to discovering the Great Comets of 1861 and 1881 and Nova V728 Scorpii 1862, he carried out wide-ranging observations of comets, double stars, variable stars, planets, minor planets, solar and lunar eclipses, transits of Mercury and Venus, Jovian satellite phenomena, lunar occultations of stars and planets, and occultations of stars by planets, and published prolifically. He also was very active in popularising astronomy, and in 1882 formed the short-lived "Australian Comet Corps", this nation's first national scientific group of any kind. In addition to his observational astronomy, Tebbutt operated a meteorological station, kept a record of floods and freshes and maintained a local time-service. In 1905 he was awarded the Jackson-Gwilt Medal and Gift by the Royal Astronomical Society for his comet and double star work and his on-going contribution to Australian astronomy (Orchiston 1988a; Tebbutt 1908; White 1979).

Just two years apart in age, Russell and Tebbutt were friends during the early 1870s, but later in the decade there was a gradual breakdown in relations. This first became apparent in 1875, when Russell commented publicly on their respective observations of the December 1874 transit of Venus, then in 1881 Russell failed to adequately acknowledge Tebbutt's discovery and subsequent observations of Comet C/1881 K1, yet another example - to Tebbutt's way of thinking - of Russell not giving credit where it was due.

From this critical date, the letters between Russell and Tebbutt became less frequent and the relationship more strained. By the mid-1880s, Russell's letters were formal and to the point: once they had commenced with "My Dear Mr Tebbutt" but now it was a terse "Dear Sir". The situation worsened in 1888 when Russell produced his classic paper on "Astronomical and meteorological workers in New South Wales, 1788 to 1860" and failed to make any mention of Tebbutt's contributions. This omission was a calculated one, for Russell was aware that between 1853 and 1860 Tebbutt made numerous observations of celestial objects and events, which were widely reported in the Sydney newspapers.

Another reason for Tebbutt's growing animosity towards Russell during the 1880s was Sydney Observatory's increasing devotion to meteorology, at the expense of astronomy. Matters came to a head in 1891 when the Sydney Morning Herald newspaper (SMH) published statistics on the number of staff employed at the Observatory in the years 1880 and 1890, total salaries paid in those two years, and the overall cost of running the Observatory for the ten years ended 1890. Tebbutt commented on these details in a "Letter to the Editor" of the SMH, but this was suppressed.

Undeterred, he expanded his letter into a pamphlet and in September 1891 published this privately. Titled, The Sydney Observatory and the "Sydney Morning Herald". A Plea for Astronomy in New South Wales, it discussed the relative expenditures and publication outputs in astronomy and meteorology, and critically examined the Observatory's overall contribution to international astronomy (Tebbutt 1891).

Figure 3. Sydney Observatory during Russell's directorship (Courtesy: RAS Library)

Despite his obvious bias, some of Tebbutt's claims were based upon fact. For example, Russell's increased focus on meteorology during the 1880s has been quantitatively documented (Orchiston 1988b), but what Tebbutt did not consider was the possibility that Russell's meteorological bias was perhaps unavoidable given pressure from politicians, farmers, and even the general public. In a new land, climatic and meteorological data were in great demand, and in rural areas livelihoods depended upon the provision of accurate weather information.

When it came to Russell's poor publications record Tebbutt was on firmer ground, as is documented in Table 1, although it is important to remember that Tebbutt's output was the envy of many a professional observatory. He was hardly your typical amateur astronomer!

Had Tebbutt's original letter to the SMH been published, it is more than likely that the matter would have died a quick death, but instead it festered for years as the pamphlet found its way onto the desks of Australian and overseas astronomers and into the libraries of politicians, academics, and others of influence.

In this way, the Observatory's perceived "ills" reached a wide audience, and the Russell-Tebbutt relationship quickly devolved into an open feud. As the Field Astronomer from the New South Wales Lands Department was to moved to observe, "... Mr Russell does not like anyone to be "near the throne"." (Brooks 1897).

Tebbutt's brash, frontal attack may not have enthused Russell but it did at least prick him into action, and in 1892 he began publishing a backlog of accumulated astronomical observations. And with the completion of the 33cm astrograph, he was able to indulge his interest in astronomical photography and immerse himself in the international Carte du Ciel Project.

For the next decade, the Russell-Tebbutt feud permeated Australian professional and amateur astronomy, and it even erupted on the pages of The Observatory. This situation only changed in 1907 with Russell's death, but by this time he had well and truly consolidated his position in New South Wales. As a senior government employee he knew the vagaries of the public service, and had the ear of Parliament. Meanwhile, he also

Table 1: Astronomical publications by Russell and Tebbutt

Astronomer	Decade		
	1870s	1880s	1890s
Russell	33	13	24
Tebbutt	75	134	110

wielded power through the Royal Society of New South Wales and the Australasian Association for the Advancement of Science, and had further influence as a long-standing member of the Senate (and one-time Vice-Chancellor) of his alma mater. Consequently, civil honours flowed his way (e.g. a C.M.G.), and he was elected an F.R.S., an honour denied Tebbutt despite his vastly superior research output.

Yet this very same research record gave Tebbutt the international supremacy that he so desired, and he was openly feted as the doyen of Australian astronomy - despite his amateur status - but his contribution to Australian astronomy and international science was only fully recognised locally in 1973 when a crater on the Moon was named after him and in 1984 when he featured on the new Australian $100 bank note.

Tebbutt's death in 1916 marked the end of an era. No longer would it be possible for an amateur astronomer, working in comparative isolation, to make a major contribution to international astronomy. The emerging world of astrophysics put paid to that prospect.

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Figure 4. View showing two of the three Windsor Observatory buildings (Orchiston Collection)

CURRENT INSTRUMENTATION AND SUPPORT ASTRONOMERS

Ray Stathakis & Stuart Ryder

The instrumentation suite of the AAO continues to be large and diverse, reflecting the wide range of science carried out at the AAT and UKST. This article summarises current instrumentation, AAO support astronomers and recent developments concerning current and future instrumentation. For more information see the AAO web pages, particularly http://www.aao.gov.au/astro/instrum.html.

There are different levels of instrument support. Normal (common user) support indicates that a support astronomer is available if required, and instrument manuals and other tools are maintained by the AAO. Expert mode indicates that observers are expected to be experienced and require minimal support, or alternatively be willing to collaborate with the instrument scientist. The level of manuals and tools is minimal. There are also some visitor instruments (e.g. Manchester Echelle, UNSWIRF and MAPPIT) which are supported by the owner institution (see the web pages for more information). Observations in service mode, where available, are typically limited to 3 hours duration and proposals can be submitted quarterly (exceptions are UKST photography and PATT 2dF observing). Observations are carried out by AAO staff.

Instrumentation

A) Imaging

WFI is a camera which operates at $f/3.3$ in the upgraded AAT prime focus unit (PFU). It uses 8 MITLL CCDs in an 8192 x 8192 15 μm pixel array, corresponding to 33 x 33 arcmin at 0.248 arcsec/pixel. It is a standalone system which is shared with the RSAA 40". The Johnson U B V R and SDSS *g r i z* filters are available. Chris Tinney is the AAO instrument scientist for WFI. WFI is available in normal and service mode.

The **Auxiliary CCD Camera** can be mounted at the AAT Cassegrain auxiliary focus with one of the AAO portable CCDs. Johnson filters are available but note that the filter wheel is operated manually from the Cassegrain cage. The image scale at $f/8$ is 6.7 arcsec/mm, corresponding to 0.16 arcsec/pixel and a 2.74 x 2.74 arcmin field of view for the Tektronix CCD. This imager is typically used in conjunction with the RGO spectrograph. Chris Tinney is the instrument scientist for the Auxiliary CCD Camera, which is available on request in normal mode.

Taurus is a Fabry-Perot interferometer which is mounted at AAT Cassegrain with either the $f/8$ or $f/15$ top ends resulting in image scales of 24.84 and 13.13 arcsec/mm respectively. Taurus uses the AAO portable CCDs. For the Tektronix at $f/8$ this corresponds to 0.6 arcsec/pixel over a 10.2 x 10.2 arcmin field of view. Taurus can be used in a number of modes: classical imaging with a range of narrow band filters, 3D line mapping with a range of narrow band etalons, or most commonly in TTF mode, which provides tunable filtering over the full optical spectrum. Blue TTF (3700 – 6500 Å) provides resolutions of R = 300 – 3000 and for Red TTF (6000 Å – 1 μm) R = 100 – 1000. An imaging polarimetry mode is also available. Joss Hawthorn is the instrument scientist for Taurus. TTF is available in normal and service mode, and imaging polarimetry is available in normal mode. Classic imaging and 3D line mapping modes are offered at expert status only.

LDSS++ (see below) is occasionally used in imaging mode, providing 0.39 arcsec/pixel with the MITLL CCD. LDSS++ is available in expert mode only.

UKST photography is mainly carried out with 4415 Tech Pan film in the OR and Hα wavebands on 6 degree square fields of view. The UKST is available in service mode. The instrument scientist is Fred Watson, and other UKST observers include Malcolm Hartley, Paul Cass and Ken Russell.

B) Multi–Object Spectroscopy

2dF is mounted at the AAT prime focus in a dedicated top end. Up to 400 targets can be observed simultaneously over a 2 degree field via optical fibres. The light is fed to two spectrographs, each with 1k x 1k 24 μm pixel Tektronix CCDs. A robot configures the next field during observing in ~ 60 minutes for 400 fibres. A suite of gratings provide R = 500 – 2000 (at 5000 Å), but grating changes during a night are not offered due to unacceptable overheads. Observing in the far red (> 8000 Å) at high resolution is not recommended, and second order setups are not offered due to image distortion at large grating angles. Ian Lewis is the 2dF instrument scientist and Terry Bridges is the project scientist. 2dF is offered in normal mode (with full support) for ATAC proposals and in service mode with an AAO observer for PATT proposals. 2dF is also available in service mode for short (< 3 hr) proposals.

LDSS++ is a multislit spectrograph used at the AAT Cassegrain with the $f/8$ top end and the AAO portable detectors. It has the highest efficiency of the current spectrographs due to the use of VPH (Volume Phase Holographic) gratings, but the resolution is fixed at 400

– 600 (at 5000 Å) depending on slit width. Up to 60 objects can be observed over a 12 x 12 arcmin area in multislit mode, or 300 objects can be observed over a 9 x 9 arcmin field of view in microslit mode. Geraint Lewis is the instrument scientist, and LDSS++ is offered in expert mode only.

C) Single-Object Spectroscopy

The **RGO** spectrograph is a long-slit spectrograph which mounts at AAT Cassegrain with the $f/8$ top end. The slit is 4 arcmin long, with 2.5 arcmin unvignetted. The RGO is used with the AAO portable CCDs. It has a medium dispersion and high dispersion camera, and the suite of gratings can provide resolutions from 1000 to 20,000 (at 5000 Å). A spectropolarimetry mode is available, and time–resolved observations (from 0.7 second period) can be carried out in time-series mode. Rapid configuration changes are possible between gratings and cameras, and the Auxiliary CCD Camera. The main disadvantage is a relatively low throughput compared to the newer spectrographs. The instrument scientist is Ray Stathakis, and the RGO is available in normal mode, and in service mode in limited configurations.

UCLES is a high resolution (R = 50,000 – 80,000) echelle spectrograph at the coude focus of the AAT. It uses the AAO portable CCDs. Gratings with 31.6 and 79 l/mm are available; they give identical resolutions, but the 79 l/mm grating allows a slit length 2.5 times longer (but with less complete wavelength coverage) than the 31.6 l/mm grating. An iodine cell is available for extremely precise velocity measurements. Stuart Ryder is the instrument scientist, and UCLES is available in normal and service mode. Polarimetry is available via the Semel Polarimeter which is a visitor instrument.

UHRF is an ultra-high resolution extension of UCLES which can be used at resolution settings of 300,000 – 940,000 through an image slicer. Efficiency is improved by observing through the UCLES slit and bypassing the slicer. With a 0.6" slit, R ~ 100,000. UHRF is used with the MITLL2A or Tektronix CCDs. Ray Stathakis is the instrument scientist and UHRF is offered in normal and service mode.

SPIRAL is an integral field spectrograph with an optic fibre feed. A field of 22 x 11 arcsec is sampled at 0.7" per fibre. SPIRAL uses the MITLL2A CCD and the RGO suite of gratings resulting in resolutions R = 1000 – 10000 (at 5000 Å). David Lee is instrument scientist of SPIRAL, which is offered in expert and service mode. Note that in this case expert mode means that full support is given by the AAO staff, observers are expected to be present and train in the use of SPIRAL, and rapid feedback on observations is requested to monitor instrument quality. SPIRAL is recommended as an alternative option to the RGO spectrograph.

LDSS++ (see above) also offers single object spectroscopy in expert mode. LDSS++ has a 12 arcmin long slit, or shorter slit lengths can be used in nod-and-shuffle mode.

D) Detectors

WFI and 2dF have dedicated detectors described above. Other AAO instruments use the portable CCDs. Currently available CCDs are the Tektronix (best blue response, 1K x 1K 24 μm pixels), MITLL2A (blue and red response) and MITLL3 (best red response but no binning available), both 2K x 4K 15 μm pixels. The Thomson CCDs (poorest response, 1K x 1K 15 μm pixels) are available but rarely used.

Efficiency curves for the AAO portable detectors.

Support Astronomers

Brian Boyle supports 2dF and the RGO. Other duties include being Director of the AAO. His research interests include QSOs, AGN and the 2dF Quasar Redshift Survey.

Terry Bridges is project scientist for 2dF. His research interests are globular clusters and galaxy dynamics, galaxy clusters and the 2dF Galaxy Redshift Survey.

Russell Cannon supports 2dF and SPIRAL. His research interests include globular clusters, local group galaxies, and the 2dF Galaxy Redshift Survey.

Elizabeth Corbett supports 2dF. She is also coordinator for service observing and on-line instrument information and organises colloquia. Her main research interest is multi-wave observations of AGN.

Joss Hawthorn is instrument scientist for Taurus and TTF. His research interests include Hα clouds, star formation and the 2dF Galaxy Redshift Survey.

Lucyna Kedziora supports TTF and organises joint AAO/ATNF colloquia. Her main research interest is Intra-Day Variables.

Geraint Lewis is instrument scientist for LDSS++ and supports 2dF. He is the scheduler for the AAT. His primary research areas are gravitational lensing, dusty AGN and galaxy dynamics.

Stuart Ryder is instrument scientist for UCLES and also supports UHRF. He is the AAO Technical Secretary on PATT and ATAC. He is commissioning scientist for IRIS 2, and his research interests include infrared and radio studies of star formation regions and spiral galaxies.

Will Saunders is commissioning scientist for 6dF. His research interests include dynamics of the local universe.

Ray Stathakis is instrument scientist for the RGO spectrograph and for UHRF. She also supports UCLES. Other duties include editor of the AAO newsletter. Her main research interest is the nature and role of supernovae.

Chris Tinney is AAO instrument scientist for WFI, PFU and the Auxiliary CCD Camera, and is project scientist for IRIS2, CYCLOPS and MACRO. Chris has just been appointed head of astronomy. His research interests include brown dwarfs, extrasolar planets and CCD astrometry.

Fred Watson supports UKST photography and 2dF. He is project scientist for 6dF and as Astronomer in Charge at site oversees observer support at the telescopes. His research interests include history of astronomy and instrumentation.

Other staff who mostly work in instrument development but might be assigned telescope support include **Jeremy Bailey** (polarimetry with various instruments) **David Lee** (SPIRAL), **Ian Lewis** (2dF) and **Scott Croom** (2dF).

NEW AAT ALARM SYSTEM

Allan Lane

Observers can now contact the afternoon shift technician or night assistant by using the Technical Support Call facility — a button which sets off an alarm throughout the AAT building. This will be particularly useful on weekend afternoons or during cloudy weather when the technical staff are working on equipment in laboratories and workshops.

The call facility is actually part of the alarm system, which monitors the various systems and equipment throughout the AAT and UKST. It uses relay logic for reliability and simplicity and is powered via its own battery that is maintained on a float charge. There are displays located in most work areas around the AAT, with both audible and visual signals to alert the operational staff to the zone in which a malfunction has been detected and the urgency of that malfunction. A fault is considered urgent if it is likely to affect observing, or constitutes an imminent threat to equipment or staff. In this case, an audible alarm goes off as well as a flashing red lamp indicating the problem zone. The aim of the audible alarm is to attract the attention of staff who can then silence the audible alarm within that area with a button marked BUZZ OFF. The flashing red lamp remains flashing. In the event of another urgent alarm occurring within another area the audible alarm is again enabled and requires another operation of the BUZZ OFF button to turn it off.

When the appropriate staff member starts working on the problem, the RA (receive attention) button is pressed which turns off all audible alarms and changes the flashing red lamp to a steady red lamp. The non-urgent alarm is of a similar setup except that there is no audible alarm and the lamp is yellow. Once the condition that has caused the alarm has been cleared all indicators are automatically reset.

INSTRUMENTATION NEWS IN BRIEF

2dF

A scheduled two-month downtime for 2dF has allowed much needed maintenance, including repair of fibres and retractors resulting in 799 of the 800 fibres being available in September. Problems with observing in the far red and at second order have been traced to a significant deterioration in image quality at high grating angle. First order (blaze to collimator) is unaffected.

UKST

6dF is on track to be commissioned next semester.

SPIRAL

SPIRAL is now fully commissioned and available as an expert instrument and through service. The level of sky subtraction accuracy will be quantified in tests early next year, but initial observations are looking very promising (see for instance the article on page 4).

RGO

As the general workhorse for the AAT, the RGO spectrograph continues to attract a regular flow of users in both normal and service mode. The RGO spectrograph is one of the original instruments on the AAT, and the need to replace its role is well recognised (particularly by the heroic staff at the AAT). With the need for the AAO to rationalise its instrumentation suite, Ray Stathakis will be surveying users to investigate the requirements of projects typically carried out on the RGO, and to what extent these projects could be carried out on newer instruments such as SPIRAL. Interested parties are welcome to contact her at ras@aaoepp.aao.gov.au.

Detectors

Nod and shuffle mode has experienced some problems recently due to CCD controller errors. As a consequence, this observing mode is offered at present on a best efforts basis, and observers are recommended to prepare backup programs. This problem will be fixed with the delivery of the AAO-2 CCD controllers in 2001. The MITLL3 CCD was unavailable for a period to remove contamination from the dewar. It has now been recommissioned in a new dewar. Work on setting up the 2K x 4K blue-sensitive EEV CCD is expected to start soon.

AAΩ

A draft User Requirements document for AAΩ, the proposed 2dF upgrade with new spectrographs, larger detectors, and a new wide-field IFU, has been prepared and responses from the user community are now being sought (deadline 6 November). See the AAΩ web page http://www.aao.gov.au/local/www/aaomega/ or contact Project Scientist David Lee (dl@aaoepp.aao.gov.au).

See also articles on WFI and IRIS2.

WFI+PFU UPDATE

Chris Tinney

As noted in the “Stop Press” section of the last Newsletter, the Wide Field Imager (WFI) had its first commissioning run attached to the Prime Focus Unit (PFU) on the AAT in August.

As is usual for these runs, the only clear sky we saw in five nights occurred in the first 3 hours, when almost nothing was working optimally. We did manage to focus the AAT on WFI, and acquire images of a few astrometric fields before the cloud and fog rolled in. Excitingly, these showed that 1" images can be delivered over the whole mosaic.

We then spent the rest of the five nights playing with WFI’s vacuum and cryogenics, and taking domeflats! As a result we were unable to address many of the areas in the detailed commissioning plan we had prepared in advance. Interested potential observers can read the plan, and the conclusions we have drawn from the data we obtained at the AAO WFI page (http://www.aao.gov.au/local/www/cgt/wfi/wfi_pfu.html) by clicking on the “August 2000 Wash Up” link. Pictures of WFI and PFU taken during the run can be found at the other “Commissioning Run” links on the AAO WFI page. The next commissioning run for WFI+PFU is over Christmas, after a successful period on the RSAA 40". WFI+PFU is available for proposals in both normal and service mode.

Special thanks for all their work on WFI, PFU and the commissioning run must go to Mark Downing, Peter Young, Gary Da Costa & Peter Conroy (RSAA) and Rob Patterson, Serge Ivanov, Chris McCowage, Alan Lankshear, Brendan Jones, and Gordon Schafer (AAO).

JAVA AT THE AAO

Anthony Dunk

If you've spent much time using the internet, then at some stage you've probably played around with Java applets that run within your browser. But these days Java is much more than just a toy to jazz up web pages. It's a full-blown programming language that is in direct competition to C++ in many application areas. It comes with extensive libraries providing support for user interfaces, communications, and multi-threading.

Unlike C or C++, which are both compiled to machine-code, Java is compiled to a machine-independent code — called "byte-code". This means that a Java program, once compiled, can be run on any platform that supports Java — Windows, Unix, Mac, or whatever.

Compared to C, Java is a very recent language. It was only introduced in 1995, but has since enjoyed a rapid acceptance by the software development community due to its flexibility, power, and its similarity to C/C++. The Java language is really a distillation of the best features of both C and C++. However while C++ suffers

The GUI user interface for IRIS2 — an example of the use of Java at the AAO.

from being a super-set of C, Java is a completely new language and is much more strongly object–oriented than C++.

Traditionally, user interfaces at the AAO were written in the scripting language Tcl/Tk. While this allows quick development of interfaces, it lacks much of the structure and power of a full object–oriented programming language like Java. Java comes with a big range of modern GUI (graphical user interface) components which allow the construction of very high quality GUIs.

With the aim of keeping up with the latest developments in the industry, the software group at Epping has been building expertise in Java over the past three years. During 1999, Tony Farrell put together an interface between Java and the AAO's real–time control system — Drama. Subsequently, both Jeremy Bailey and myself have been using Java and the Swing GUI libraries for user interfaces on the IRIS2 project. Jeremy has also written a user interface for CCD charge shuffling in Java (see August newsletter) and has written a new telescope control interface. Keith Shortridge has also played his part in Java at the AAO with his ingenious crossword applet which made an appearance in an earlier edition of this newsletter.

Java is also fast becoming a language of choice amongst the astronomy community world–wide. For example, Gemini uses Java extensively for its user interface software, taking advantage of the language's networking capabilities to facilitate remote observing and searches of on-line star catalogues.

Although the AAO team still writes the low–level Drama tasks in C and C++, Java, with its multi-platform nature and excellent user interface libraries, is helping to build powerful and flexible instrument control software. IRIS2 will be the first major instrument project at the AAO to take advantage of Java.

IRIS2 UPDATE

Chris Tinney

The fused-silica grisms arrive

The two fused-silica grisms arrived in early October. These cover the H & K, and J & H bands respectively and have resolutions R = 1500. The three grisms still to arrive are composed of sapphire and cover the J, H and K bands at higher resolution (R ~ 2400). See the IRIS2 home page (http://www.aao.gov.au/local/www/cgt/iris2/iris2.html) for more information including a first guess at IRIS2 sensitivity with the silica prisms.

Commissioning

Up until the middle of this year, the AAO had planned to begin commissioning of IRIS2 in Dec–Jan of Semester 2000B. Unfortunately delays in a few critical IRIS2 areas have meant that commissioning has had to be postponed to an earliest date of March 2001, with SRSO following soon after.

Share-risk service observing

The call for Shared Risks Service Observing [SRSO] for December–January time resulted in a healthy 17 proposals. These will now be held over and executed if possible, and new SRSO proposals will be accepted at the usual Dec 15 service observing deadline.

As a reminder, for IRIS2 SRSO, there is no limit on the amount of time which may be requested (from one hour to several nights), and the proposals will be ranked by the usual service refereeing process. The actual selection of proposals for execution will be made by the IRIS2 commissioning team, depending on observing conditions and the capabilities of IRIS2 at the time. Proposals to use IRIS2 in shared risks visitor mode in 2001A will be considered by the TACs, but may be allocated time in service mode.

Right: The new fused-silica grisms for IRIS2 which arrived in October.

LETTER FROM COONABARABRAN

Rhonda Martin

With a body clock still somewhere out over the Pacific and a brain totally out of whack, it is good to return to where there is actually a sky with stars in it! Searching a Paris sky desperately for something familiar (I mean, even the sun is in the wrong place!) I latched onto Orion with abandon and then saw with horror that he was the wrong way up! What is happening here! After a few weeks of this, I felt a grudging admiration for northern astronomers who can actually find anything in a sky so full of lightspill and pollution.

Even in high Switzerland, the stars are weak, mild objects compared to the blazing, dark nights of Terra Australis and I missed them like mad. What shocked me to some extent, is that I received the impression that if most northerners saw a clear sky, unfettered by light and pollution, they would feel insecure and unsafe, a feeling I have also met in Australian cities where the same conditions occur.

But enough of that — the sun is now back in its right place and Orion the right way up! Ed Penny is also tasting the delights of Europe on long–service leave and meeting all the wonderful, rainy weather that has been deluging that part of the world. Succinct postcards mainly tell us about the 'bl....weather!', but we are sure he and Ros will have a great time in spite of it all. Christmas fast approaches and our annual French deluge is scheduled as our friends from Meudon arrive to taste an Australian summer sky — let us hope it is a clear one.

EVENTS IN EPPING

Helen Woods

In the last Newsletter, we welcomed Marilyn Campbell to the AAO as our new receptionist. However very soon afterwards, Greta Simms, who had returned from maternity leave, reluctantly resigned. Marilyn proved well and truly up to the challenge of stepping into Greta's shoes and, with some training from Carolyn, who has temporarily returned to the AAO (from China) Marilyn is now our new personnel officer. To replace Marilyn on the reception desk, we are happy to welcome Shanthi Iyer. Shanthi is still employed by "Select Appointments" but she will be at the AAO for the foreseeable future.

At the same time that Greta resigned, we were also sad to farewell Helen Johnston who has been with the AAO since early 1996 as an ARC/PPARC fellow. By becoming a part-time member of staff after the birth of her daughter Madeleine in November 1996, Helen managed to turn a two-year fellowship into a four and a half year one. Alluding to this and the birth of her second baby in 1997 at a farewell lunch in her and Greta's honour, she commented that her time at the AAO had been productive in more ways than one! Helen has taken up a position at Sydney University and we wish her all the best.

Niki Frampton, who has been with the our software section for 2 years now, has also decided to leave the AAO. Niki will be moving to Lake Technology in the city where she will be working as a software engineer. We wish Niki all the best in her new job.

We are delighted to announce that David Malin, the AAO's photographic scientist, was recently awarded one of photography's most prestigious prizes, the Lennart Nilsson Award. The award was made in recognition of Professor Malin's achievements in the field of astronomical photography and was presented to him in Stockholm, where he also presented a special lecture at the Nobel Forum at the Karolinska Institute.

We congratulate Chris Tinney on his appointment as Head of Astronomy.

LIBRARY NEWS

Sandra Ricketts

Once again, quite a number of new books have been received in the AAO library. While the majority of books are on astronomy, the library also purchases books on engineering, computers, instrumentation etc. When you are in the library it may seem that there are not many books on these other areas, but that is because they may not live in there, rather elsewhere in the AAO, such as the Electronics area. If this is the case, the location is noted on the catalogue entry, and can be seen when searching using the web search engine (http://www.aao.gov.au/library/libsearch.html). (Of course the book you want may simply be on loan to someone, so please ask the librarian if you can't find it)

From 2001, the telescope library will no longer receive hard copy issues of the major astronomy journals - Astronomy Journal, Astrophysical Journal and Supplement, Astronomy & Astrophysics, Publications of the Astronomical Society of the Pacific, and Monthly Notices of the Royal Astronomical Society . They will be available on the web - go to the library's web page, click on AAO Library Resources, then On-line journals (http://www.aao.gov.au/AAO/local/www/lib/jnls.html). The hard copy will of course continue to be received at Epping. Apart from cost savings, this move will help to ease the space problems in the telescope library.

AAO NEWSLETTER PUZZLE

Past, present and future AAT instruments are embedded in this puzzle. The winner will identify the largest number of instruments. Note that where instruments share names (e.g. IRIS, IRIS2) the latest version is used. Also, numerals and other symbols are spelt out.

For clues, see the article on page 12. Please fax your solution by January 15, 2001, to +61 2 9372 4880. The winner will receive the 2001 AAO Calendar.

Thanks to Katrina Tapia-Sealey for this puzzle.

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G Y D G E K R T A E F J V T H I Z C L P K S A Y Y
X A S V Z H S E M E L P O L A R I M E T E R V U C
X Z V H W L K B T V F B W W D I Z Z T L T H L R F
P U N S W I R F F E R A T S G A Y V C F D Y O G M
P N S B B M N S D U M J S P R H K U U S H Y S I G
G F I A X A Q D W E G I I I H D P E D P T L T J D
O J E L Q I H B U I T Z R R G X G I A Z B A O I H
E N L X I B I F O T U A I A U X V R B C U K U V A
X V E K S R B L U S M C F L L H G T H R G J B Y B
Q X X L U R G O F G I E Q T Y O I U U M D E O D F
M R C I L C V J U T H Y H A T P P S C P C F I E O
M Y I V P E R P V D L V P O P U F D G D S D T J T
W A V F S K H P P O R C H A G A J Z L F F X N P Q
M Y G L U C U C L M X P M L B N U S K E R I D D R
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L T X I P X C O F R L A Y B R U E I D T Q F R Q S
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P W B S S F H S M M E T Z D K Y I X J S Y S R A O
X W H Z D U O F E R W H S F L U U A F G K W C N H
B J Z D L M D R O Q L F B E Y Z A Y A T P O T I W
O W Y A V O I T S W M E I C H O W G B X F E J A A
U N B M W S Z Q Z S U H B Z M C W F E I P A N P O
T V C T N O T D E E R H T E X V N K S R B L U S M
C H H G J B Y B Q X X F G G I E Q A Y U M D E O D
F M R C I C V J U T H A Y H A C P C M I E O M Y I
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THE BACK PAGE

Learning more about planets outside our Solar System

Venus from Marina 10, 1974 (NASA)

The observation of microlensing events is emerging as a new and powerful tool in discovering and learning about extrasolar planets. Microlensing can detect planets at much greater distances than other techniques, and can reveal the type of atmosphere and even the phase of the planet. See the article by Lewis, Ibata and Ashton on page 3.

editor RAY STATHAKIS editorial assistant SANDRA RICKETTS

ISSN 0728-5833
Published by ANGLO-AUSTRALIAN OBSERVATORY
PO Box 296 Epping, NSW 1710 Australia

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

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

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