The Manchester Echelle Spectrometer has been used in its multislit mode to study the cometary globules in the Helix Nebula. This position-velocity map was obtained using a multislit mask to define ten parallel, east-west slit positions obtained from the rectangular region indicated on the AAT image of the Helix, and a narrow band interference filter isolated the $[\text{N} \text{II}] \lambda 6584$ Å emission line. See page 5 for details.
Slightly reversing the trend of the past few newsletters, science articles form the bulk of the material in this edition of the newsletter. This is very encouraging and demonstrates that, while the AAO remains at the forefront of instrumentation development, we have not lost sight of the goal of delivering first-class science.

Jeremy Bailey’s article on spectroastrometry demonstrates that even ‘venerable’ instrumentation such as the 82cm camera on the RGO spectrograph can still yield impressive results through innovative observational techniques. Jeremy’s results directly refute those who would say that sub-arcsecond astronomy in the optical is impossible from the AAT! In a separate article, Jeremy Bailey also shows that observations made with another venerable instrument, IRIS, may also have fundamental implications for no less a matter than the origin of life itself.

The continued success of these instruments demonstrates the AAO’s ongoing commitment to supporting a wide instrumental base. Although rationalisation of instrumentation should occur, the AAO’s focus has always been to deliver the minimum effective instrumentation suite, while allowing it to respond rapidly to innovative techniques and new scientific opportunities. The article by Gordon Robertson on the proposed upgrade to MAPPIT illustrates this point well. Indeed, the AAO’s involvement in instrumentation using holographic techniques (e.g. the volume phase holographic grating in LDSS++), integral field units (SPIRAL) and multi-layer coatings (Rugate filters) would not have been possible if the instrumentation base had been reduced to one or two instruments. All these developments will play key roles in maximising the science obtained from future AAO instrumentation.

Some of these science gains will come sooner rather than later as the LDSS++ upgrade (complete with VPH grating) will play a major part in the AAO’s plans to capitalise on the opportunity provided by the Hubble Deep Field South (HDF-S). The HST will observe the HDF-S in October 1998 and two key AAO support observations will be the UCLES high-resolution spectroscopy of the QSO Q2234–6123 and the LDSS++ survey spectroscopy of the HDF-S and the flanking fields region. The UCLES observations are scheduled for July/August and the LDSS++ observations will take place in October. In the true spirit of the Hubble Deep Field, the AAO plans to make the results and data from these observations publicly available as quickly as possible after the observations. The AAO has set up a WWW page (http://www.aao.gov.au/hdfs) where all information will be posted. Watch this space!

Those visiting our WWW site will also note that it has undergone a major re-design. This was done to make it even easier to access information about the AAO from our WWW pages. For some time now the WWW has formed our principal means of providing information and the new WWW pages reflect our continuing commitment to improve the service we provide. The AAO would very much welcome comments from users of the site via the feedback page provided on the WWW.

The AAO Service Program continues to receive a large number of applications for service observations. 10 service nights have been scheduled for semester 98B for observations with the RGO spectrograph, Prime focus CCD imaging, Taurus and the two-degree field (2dF) facility.

We are pleased to announce that 2dF is now included in the Service Program. 2dF service proposals may be submitted for programs that require between one and three hours of observing time. 2dF service observations will be taken by an AAO support astronomer. The data will be reduced using the 2dfdr pipeline-reduction package and made available to the proposers by anonymous ftp, normally within a week of the observations.

We advise IRIS users that IRIS will be fully decommissioned in 1999 and has now been withdrawn from the service program.


The next deadline for service proposals is September 15th 1998.
SPECTRO-ASTROMETRY: STUDYING STRUCTURE ON MILLI-ARCSECOND SCALES WITH THE AAT
Jeremy Bailey (AAO)

It is generally thought that the smallest spatial scale which can be directly studied in an astronomical source is set by the point source image size which is determined either by seeing or by the diffraction limit of the telescope. Thus higher resolution studies are possible only by using adaptive optics techniques to reduce the size of the seeing disk or by using interferometric methods to reduce the diffraction limit. However, it is possible in many cases to study structure on scales much smaller than the limits set by seeing or by the diffraction limit using the method of “spectro-astrometry”.

The basic ideas of spectro-astrometry were first proposed by Beckers (1982) in his method of “Differential Speckle Interferometry” and by Christy et al. (1983) with the method of “Chromatic Position Difference” for double stars. Both these techniques involve measuring in different ways the wavelength dependence of the position of a source. It was shown that this could potentially reveal structure below the diffraction limit, and this has been confirmed in experimental observations by Petrov et al. (1991) and by Aime et al. (1988). Despite these demonstrations the technique does not seem to be widely known and does not seem to have been previously exploited for serious astronomical research.

The essential feature of the technique is to measure the wavelength dependence of the position of an apparently unresolved source. Because this is a purely relative measurement on the same source it avoids many of the problems which limit the accuracy of conventional astrometric measurements using reference stars and can be done to a very high accuracy, in principle limited only by photonistics. The “position spectrum” derived from such an observation may show structure such as a difference in position between a line and the adjacent continuum or variation in position across a line profile. This can arise from a number of reasons, but a simple case to consider is that of a binary star in which a spectral line is present in one component but not in the other. The relative contribution of the two stars is then different on the continuum and the line and the centroid position will shift. The separation of the binary may be much less than the seeing disk size, but the position shift between line and continuum is nevertheless measurable given good S/N observations.

At the AAT spectro-astrometric observations are obtained as conventional long slit CCD spectra using the RGO spectrograph and 82cm camera. The 82cm camera is chosen mostly because it gives small spatial pixels (0.23 arcsec with the Tektronix CCD). Excellent sampling of the spatial profile is necessary in order to

Figure 1. Spectro-astrometry of Mira (o Ceti) from observations taken on the AAT on 1996 Aug 25. The upper panel shows the total intensity spectrum, below this is the East-West component of the position spectrum. The intensity and position spectrum have been decomposed into spectra for the two binary components Mira A and Mira B (shown in the lower two panels). The positions assumed for the two components to perform the decomposition are shown as dashed lines on the position spectrum. The data were taken in 3 arcsec seeing.
measure the spatial position to an accuracy which may be very much less than the pixel size. The position spectrum is derived by fitting a gaussian to the spatial profile at each wavelength. Observations are repeated with the instrument rotated through 180°. Subtracting the two position spectra removes any instrumental effects arising from misalignment of the spectrum with the CCD rows, curvature in the spectrum, or any departure of the CCD pixels from a regular grid. A second set of observations at 90° and 270° slit orientations allow the orthogonal component of the position spectrum to be measured.

An example of what spectro-astrometry can do is provided by the data on Mira (ο Ceti) obtained with the AAT on 1996 Aug 25 (figure 1). This shows the EW component of the position spectrum which contains considerable structure arising from the fact that Mira is a binary system with a separation of about 0.6 arcsec with the two components having quite different spectra. Mira A is an M-type star with strong TiO bands, whereas Mira B has a flat continuum with emission lines. Thus at the peak of the Hβ emission or in the troughs of the TiO absorption the contribution of Mira B is at a maximum and the position of the photocenter moves towards Mira B, whereas at other wavelengths the photocenter will be nearer Mira A.

Given the intensity and position spectra it is possible to split the intensity spectrum into its two components if we know the position of the two stars on the same scale on which the position spectrum is plotted. Generally, since this scale has an arbitrary zero point, we don’t have independent knowledge of these positions, but we may at least know the binary separation. In the case of Mira we have this information from speckle measurements (Karovska et al. 1990) which give the separation as 620 mas in PA 111°, and hence 580 mas in the EW component shown in the figure. We can then adjust the position of the two stars (keeping the separation fixed) until we get a clean decomposition of the spectrum — in this case one in which the TiO bands are all in one component. The result of this decomposition is shown in figure 1. It shows the P-Cygni profile of the Hβ emission line. Interestingly it also shows the presence of the He I line at 4921 Å. This could not have been inferred from the intensity spectrum alone. It appears in the decomposition mostly because it is a feature in the position spectrum.

The method has also been used to study pre-main-sequence stars. Pre-main-sequence binaries are easily revealed by these observations since they show a broad (sometimes double) feature in the position spectrum on the Hα line as a result of the different profile of the line in the two stars. Using this method a survey of southern pre-main-sequence stars has led to the discovery of several new binaries. It is possible to detect binaries at smaller separations (down to about 10 mas) than with other widely used techniques such as IR speckle. This opens up the possibility of finding binaries with short enough periods for orbital studies and mass determinations to be possible.

Many pre-main-sequence stars also show features in their position spectrum on the forbidden lines of [N II]
Figure 2 shows the EW and NS components of the position spectrum in the region around Hα. The complex structure on the Hα line is a combination of two effects, a binary with a separation of 100 mas in PA 120° (discovered using speckle observations by Leinert et al. (1997)) and the inner parts of a jet at PA 60°, which is part of extended bipolar outflow which can be traced to a large distance from the star by a chain of HH objects (Poetzl et al. 1989). Figure 3 shows another way of representing spectro-astrometry data – as an XY plot of the centroid position of the star through a line profile.

Spectro-astrometry can be applied to many different types of sources. Recently we have used it to study the narrow line regions of Seyfert galaxies which show structure on scales of 100 mas. The fundamental requirement is that the lines need to be well resolved, and that sufficient photons can be obtained for the desired measurement accuracy. For example to measure the position spectrum to an accuracy of 2 mas in 2 arc sec seeing requires 10⁶ photons per resolution element, which can be achieved at about magnitude 9.5 in 2000 seconds integrations. For a lower accuracy of about 10 mas observations down to about magnitude 13 are feasible with similar integration times.

References

HIGH RESOLUTION SPECTROSCOPY WITH THE MANCHESTER ECHELLE SPECTROMETER
Myfanwy Bryce (Manchester)

The Manchester echelle spectrometer (MES, Meaburn et al 1984) will celebrate 15 years of observing at the Anglo Australian Telescope in November this year. MES was originally designed to obtain spatially resolved spectra, at high spectral resolution (up to R=100 000) from faint, extended, emission line sources. The most common mode of operation entails the use of a single, long (~2.5° on the TEK CCD) slit to obtain position-velocity (p-v) maps in a single echelle order. In many
cases, a multi-slit mask can also be used; this consists of up to 10 parallel long slits, giving up to 10 overlapping p-v maps in a single exposure. The multi-slit has the multiplex advantage, but is usually restricted to cases where a single emission line can be isolated and the radial velocity range exhibited by the object is less than the equivalent velocity separation of adjacent slits (~ 150 km s$^{-1}$ for 10 slit mask). Secondary modes of use permit direct imaging, cross-dispersion and low dispersion modes and the capability of feeding the slits with fibre bundles to give full area coverage. A diagram of MES is shown in Fig. 1.

Over the past 15 years, MES has been used to observe a wide range of objects, from η Carinae to active galaxies, supernova remnants to starburst regions. Here we illustrate some of the capabilities of MES with recent results obtained from the Helix Nebula, one of the closest planetary nebulae (PNe) and from MyCn 18, a remarkable young planetary nebula.

MyCn 18 has become well known as the Hourglass nebula, due to its distinctive shape as revealed in the WFPC2 imagery of Sahai et al (1995). Bryce et al (1995) obtained spectral data using a long slit aligned with the symmetry axis of the nebula, in the 87th echelle order which isolates the Hα and [N II] 6548 & 6584 ¯ emission lines, with a 1" (~ 6 km s$^{-1}$) wide slit. Data were obtained from three slit positions, on and either side of the symmetry axis. An extremely useful feature of MES is the ability to record a direct image of the slit position on the sky. This is achieved using the direct imaging mode; an image of the sky is obtained, then the MES shutter is closed and the slit driven into position, the MES shutter is opened again and the CCD exposure is completed. An example of such an image is shown in Fig. 2a. Here, one of the slit positions obtained for MyCn 18 is recorded. The p-v map obtained at this slit position is shown in Fig. 2b and reveals a hitherto unknown series of compact, emission features observed outside the main nebular shell of this PN. The knots have radial speeds of up to 500 km s$^{-1}$, the fastest so far observed from a PNe and an order of magnitude greater than typical PNe expansion velocities. Service time has been awarded to obtain very deep, continuum-subtracted images of this PNe in order to ascertain the spatial distribution of these curious knots.

The Helix nebula, at a distance of only 130 pc, is one of the closest PNe and displays a population of 'cometary globules', which are known to have dense, molecular cores (Meaburn et al, 1992; Huggins et al, 1992), within the main, expanding, ionised shell. It is not yet clear whether these are unique to the Helix or whether the Helix is the only PNe close enough that we can resolve such features. The Helix has been studied by many astronomers and MES has provided data for several such investigations. Most recently, Meaburn et al. (1998) used MES on the AAT to obtain a large dataset from the Helix globules, including several stepped multislit blocks of spectral data. These were obtained using a 10-element multislit, together with a 10 Å wide interference filter to isolate the [N II] 6584 Å emission line. Between each integration, the multislit was stepped by 1" to produce p-v maps which were then stacked to form cubes of area-velocity arrays. Subsequent analysis of these data cubes, together with detailed single slit studies of some of the largest individual knots and two lengthwise-stepped single slit cuts across the EW and NS axes of the main nebular shell showed that the cometary globules have a characteristic global expansion velocity which is smaller than that of the main [N II] ionised shell, suggesting that they appear to have been over-run by the main shell. The results are also consistent with the knots occupying a toroidal or thick disk region of space rather than having a spherical distribution. A typical 10-element p-v map is shown in the figure on the front cover.

These recent results obtained with MES on the AAT
show that this combination of telescope and instrument continues to produce innovative and exciting science. Over the years MES has been upgraded to reflect advances in technology and in May 1998, we tested the new 2000x4000 pixel MIT/LL CCD detector on MES (during a clouded out run). MES was originally designed for use with the IPCS detector which had a larger area than the GEC and TEK chips which have superseded it. With the advent of the MIT/LL chip, MES can once again be used with its full 3’ unvignetted slit length and with full order coverage in the spectral direction. After 15 years of faithful service the Manchester group are planning to take MES back to Manchester to be refurbished, replacing the BBC operating computer with a LINUX PC and improving both slit and fibre operating modes, so that MES can look forward to many more years of productive observing in combination with the AAT.

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THE 2DF QSO REDSHIFT SURVEY
S.M. Croom (Durham), L. Miller (Oxford), T. Shanks (Durham), B.J. Boyle (AAO), R.J. Smith (MSSSO) & N.S. Loaring (Oxford)

Aims of the 2dF QSO Redshift Survey
It has long been recognized that quasi-stellar objects (QSOs) may be used as effective probes of the Universe at high redshift. With telescopes such as the AAT, they are readily detectable at epochs when the Universe was only ~10% of its present age. We are therefore provided with a unique opportunity to study large-scale structure and its evolution via the clustering of QSOs. One of the main limitations on QSO clustering is that currently the largest complete QSO surveys only contain ~1000 QSOs. The 2dF instrument allows us to construct a homogeneous survey more than an order of magnitude larger than was previously available.

The 2dF QSO Redshift Survey, a collaboration of UK and Australia-based astronomers, aims to identify >25 000 QSOs over the redshift range 0.3<z<3.0, in two declination strips, each 75°5° (15 UKST survey fields), one at δ=−30° near the SGP and the second at δ=0° in the North Galactic Cap. The AAT with 2dF is observing QSO candidates selected using a multi-colour (U−b/b−R, see Fig. 1) procedure from UKST plates and films.
The principal scientific goals of the survey are:

- To determine the QSO clustering power spectrum, $P(k)$, from small scales, $\sim 2$ Mpc, to scales comparable to those probed by COBE, $\gg 1000$ Mpc.
- To trace the evolution of QSO clustering from $z=0.3$ to $z=3.0$ and to compare the observed evolution with current models for the formation of large-scale structure in the Universe. QSOs provide a unique opportunity to measure the evolution in large-scale structure over a cosmologically-significant range of epochs.
- To place new limits on the allowed values of the cosmological constant by searching for geometric distortions in the clustering of QSOs.
- To constrain $\Omega_{\text{baryon}}$ by searching for acoustic oscillation features (or “doppler peaks”) present in the power spectrum when $\Omega_{\text{baryon}}$ is a significant fraction of $\Omega_{\text{CDM}}$. The spatial position of any detected feature can be used to constrain cosmological parameters.

There are a number of other studies being carried out with the final QSO catalogue, including: accurate determination of the QSO luminosity function to $z \sim 2.2$; investigation of the radio properties of quasars; the study of broad-absorption-line quasars; and searches for gravitational lenses. The catalogue will also provide a database of objects to be followed up, for example, with high resolution spectroscopy to find Lyα and metal absorption line systems.

Construction of the catalogue

With a survey of this size, it is imperative that the photometry of the catalogue is as uniform as possible over the entire survey area. Any systematic errors in photometry could be translated into errors in measurements of large-scale structure. The photometric QSO candidate catalogue has been constructed using $b_J$, $U$ and $R$ UKST plates and films (Croom 1997; Smith 1998). We used the UKST $b_J$ survey plates, together with deep $U$ plates and films.
obtained specifically for this project and \( R \) plates from the 2nd Epoch Sky Survey and Tech Pan films. All the plates and films, a total of \( \sim 160 \), were scanned by APM. Particular attention was paid to correcting field effects (e.g. variable desensitization) in the photographic data, in order to produce a highly uniform photometric catalogue. Independent CCD sequences were obtained in all 30 UKST survey field areas in order to calibrate the APM photometry.

2dF observes QSO candidates in the magnitude range \( 18.25 < b_J < 20.85 \). Observations are carried out in collaboration with the 2dF Galaxy Redshift Survey, as the Quasar Survey area is included within the Galaxy Survey area. By combining the galaxy and QSO catalogues and using a sophisticated tiling algorithm to decide on the centres of individual 2dF fields, we can significantly reduce the total number of nights required to complete the two projects. The 2dF data are automatically reduced using the AAO pipeline reduction software and redshifts are determined automatically using software developed specifically for this project. QSO candidates brighter than \( b_J = 18.25 \) are observed with FLAIR on the UKST, while close pairs of objects are followed up using the RGO spectrograph on the AAT and 2.3m ANU Telescope, as 2dF cannot simultaneously observe objects separated by less than \( \sim 20'' \).

**Results to date**

We have currently identified over 1200 QSOs from the observations made so far, representing only 4% of the final survey. More than 1000 of these are from 2dF observations. This already makes the survey the largest homogeneously selected catalogue of QSOs in existence. Fig. 2 shows two example 2dF spectra from recent observations with 2dF, while the spatial distribution of currently identified 2dF QSOs in the Southern strip is shown in Fig. 3. QSO clustering is already detectable in this distribution at a statistically significant level.

From previously known QSOs in the survey region we estimate that the survey should be 93% complete over the redshift range \( 0.3 < z < 2.2 \) (see Fig. 1), with the completeness declining out to \( z \sim 3 \). Over 50% of the QSO candidates are identified as QSOs from the 2dF spectroscopy, which compares favourably with previous similarly selected samples. The number-redshift relation of the currently observed 2dF QSOs shows no indication of redshift dependent selection problems and a significant number of QSOs detected out to \( z = 3 \). The number-magnitude relation for the 2dF QSOs shows good agreement with the Durham/AAT QSO sample,
consistent with the estimates of completeness for the 2dF QSO survey. Preliminary measurements of clustering show a significant signal, with no detectable evolution of clustering as a function of redshift, consistent with previous measurements of QSO clustering (Croom & Shanks 1996). However, it should be noted that the current data are not yet ideal for clustering measurements, as the 2dF fields that have been observed to date do not cover a contiguous area.

Close pairs of QSOs are potentially some of the most interesting objects in our catalogue, as the number of gravitationally lensed QSOs in our catalogue will place further constraints on the value of the cosmological constant. So we have obtained spectroscopy of the close pairs in our QSO candidate catalogue using the RGO spectrograph on the AAT and the 2.3m ANU Telescope. This program has already discovered 10 close (<20") QSO pairs. In particular it has revealed one interesting pair of QSOs with identical redshifts; both have \( z = 0.89 \) and are separated by only 17": their spectra are shown in Fig. 4. This object could be gravitationally lensed, and we are currently following it up with further observations.

With 2dF now running in an operational mode rather than commissioning, the rate at which QSO redshifts are being obtained will increase further, until the survey is completed towards the end of 2000.

You can keep up to date with current progress by looking at the 2dF QSO Survey Home Page at http://msowww.anu.edu.au/~rsmith/QSO_Survey/qso_surv.html.

**References**


**CIRCULAR POLARIZATION AND THE ORIGIN OF LIFE**

Jeremy Bailey

The chemistry of life is based on a fundamental asymmetry. While many organic molecules are asymmetric and can exist in two distinct mirror image forms (enantiomers), living organisms invariably make only one of the two forms. Thus the amino acids which form the building blocks of proteins are all in the left handed or L-configuration, whereas the sugars, including ribose and deoxyribose which are important components of RNA and DNA, are always in the right handed or D-configuration. However, if the same substances are synthesized in the laboratory from simple (symmetric) precursors, an equal mixture of left handed and right handed molecules (known as a racemic mixture) is formed. This single handedness (or homochirality) is fundamental to life, but its origin poses a problem. Since chemical reactions only make homochiral products starting from other homochiral starting materials, it is difficult to understand how the homochirality of biological molecules first appeared.

A specific difficulty has become apparent with experiments that attempt to simulate the early stages of the origin of life (the so-called “RNA world” model). RNA molecules, placed in a solution of the four nucleotides which are the building blocks of RNA, can under certain circumstances, assemble a complementary RNA strand thus replicating the information in the original molecule and providing a possible model for the earliest genes. But these experiments are only successful if homochiral nucleotides are used, and are inhibited if the nucleotides are racemic (Joyce et al. 1984). This means that we cannot appeal to evolution by Darwinian selection as the mechanism by which one handedness is selected, as homochirality is a prerequisite for the replication process which is required for such selection to operate. Arguments like this lead many researchers to conclude the homochirality must have preceded life, but this conclusion might be avoided if a pre-RNA-world using a different type of genetic material without the same chiral constraints preceded the RNA-world.

One possible origin for a preferred handedness is the fundamental asymmetry in the laws of physics provided by parity violation in weak interactions. The weak neutral current interaction, introduced in the Weinberg-Salam electro-weak unification model, leads to a tiny asymmetry in the forces determining the structure of molecules. It has been calculated that this will lead to an excess of L-amino acids of one molecule in \( 10^{17} \) and some researchers think this could be amplified sufficiently to account for the origin of homochirality (Kondepudi and Nelson, 1985), though most are sceptical that such small effects can be of any significance.

It was discovered in 1930 that the action of circularly polarized light could preferentially destroy molecules of one handedness. This asymmetric photolysis has been demonstrated in a number of experiments including some which use amino acids (e.g. Flores,
Bonner and Massey, 1977). However, no source of circularly polarized light is known which could have had a significant effect on the early Earth. The difficulty in accounting for homochirality with any process which could have operated on Earth has led to the suggestion, first proposed by Bonner and Rubenstein (1987), of an extraterrestrial origin.

The Miller-Urey experiments in the 1950s showed how prebiotic organic molecules might have been formed by processes such as electric discharges in the atmosphere. These experiments assumed a reducing atmosphere containing methane, ammonia and hydrogen, but current ideas on the early atmosphere suggest it was in fact composed mostly of CO and N\textsubscript{2}. Such an atmospheric composition gives far lower yields of organic material in Miller-Urey processes. At the same time it has been discovered that organic molecules are common in molecular clouds, comets and some meteorites. In the first few hundred million years of the solar system, the heavy bombardment phase, substantial amounts of this material would have been deposited on the surface of the Earth, and could well have provided comparable quantities of organic material to that produced locally (Chyba and Sagan 1992). This material might have brought to Earth a preferred handedness which originated in interstellar space.

Strong support for this view has recently come from the detection of an excess of L-amino acids in the Murchison meteorite, a meteorite which fell near the small town of Murchison, Victoria in 1969. This meteorite has been found to contain an extraordinary variety of organic molecules including many amino acids. Previous reports of an excess of the L-form of common protein amino acids such as alanine, have in the past generally been dismissed as due to contamination by terrestrial biological material. To avoid these problems Cronin and Pizzarello (1997) studied an amino acid which is present in Murchison, but not known to occur in terrestrial material. They found clear excesses of the L-form in this and several other amino acids. Since the meteorite is 4.5 billion years old, it provides evidence of a preferred handedness existing in solar system material before the origin of life.

Bonner and Rubenstein originally suggested that circularly polarized light produced by supernova remnants or pulsars, as a result of the intense magnetic field of the neutron star, might be the source of the chiral asymmetry. However, observations of the Crab nebula and its pulsar, the best example of such a source, do not show any circular polarization at visible wavelengths (although the linear polarization is high).

Bailey et al. (1998) have recently advocated an alternative source of circular polarization as the source of the asymmetry. High circular polarization has been observed with the AAT in reflection nebulae in the Orion OMC-1 region (described in AAO newsletter 81 by Chrysostomou et al.). This is a region of active star formation, and a region in which organic molecules are known to be present. It may well resemble the environment in which our own solar system formed.

The circular polarization observations were made at IR wavelengths, since the dust obscuration prevents OMC-1 being seen at shorter wavelengths. However, it is UV light in the 200 — 230nm wavelength region which is required to select amino acid enantiomers. Dust scattering can introduce circular polarization as a result of spherical dust grains scattering light that is already linearly polarized, or if non-spherical grains are aligned by a magnetic field. Either or both of these mechanisms could be operating in OMC-1, and calculations show that either mechanism could give rise to UV circular polarization as high as that in the IR with reasonable assumptions about the grain properties.

These results therefore suggest that the proto-solar system might have acquired an excess of L-amino acids as a result of circularly polarized UV light scattered from a nearby star. Some of these molecules would then be deposited onto the surface of the Earth during the heavy bombardment phase. On Earth the material will racemize on timescales of 10\textsuperscript{7} to 10\textsuperscript{9} years, but nevertheless the continual supply of material from space will build up a small global excess of L-amino acids in the oceans. Locally, impacts of small comets could provide high concentrations of organic material with higher excesses which might be relevant to the origin of life. Current evidence for the earliest life on Earth is at about 3.8 billion years ago, towards the end of the heavy bombardment phase, and entirely consistent with the idea that impact delivered material was important. Much earlier, and large impacts would probably wipe out any developing life. Much later, and the impact rate would be too low to maintain a significant chiral asymmetry against racemization of the material.

References

MAPPIT 2 WAVEFRONT SENSOR COMMISSIONING
Gordon Robertson, Tim Bedding, Andrew Jacob (Sydney University), John Barton (AAO)

Mappit is an interferometer, installed at the coudé focus of the AAT, and dedicated to high resolution imaging. It uses the principle of Non-Redundant Masking, and is able to reach the diffraction limit of the telescope (about 0.03 arcsec, or 30 mas (milli-arcsec)) for observations of bright stars. Its applications have included:

- Determination of the angular diameters of a number of late-type stars (in the range 27 to 57 mas). Angular diameters are needed for calculation of effective temperatures.
- Participation in a collaboration (Bedding et al, 1997) which showed that the southern M giant R Dor has the largest angular diameter of any star (after the sun). Betelgeuse was long thought to be the largest.
- Confirmation of the hot-spots on the surface of Betelgeuse, which were first detected by observers from the Cambridge group using the WHT. (e.g. Wilson et al, 1997). The hotspots are thought to be due to giant convective cells in the extended stellar atmosphere.
- Clear detection of binarity of β Cen, at a separation of 15 mas. This separation is half of the minimum binary separation which can be determined by speckle interferometry with a 4m-class telescope.
- Determination of angular diameter as a function of wavelength for R Dor, from simultaneous wavelength-dispersed observations. The results are being compared with theoretical models of the stellar atmosphere.

We are now developing a new system, called Mappit 2, which will combine the existing interferometer with a Shack-Hartmann wavefront sensor (Robertson 1997). The wavefront sensor will determine the instantaneous wavefront distortions caused by the atmosphere along a 6 cm wide strip across the AAT aperture. By restricting the sensor lenslets to a 1-dimensional strip, we are able to achieve 100% duty cycle from the CCD, which produces a continuous readout of successive short exposures. Two-dimensional images can be built up by combining 1-dimensional data taken at a number of sky position angles.

Via a beamsplitter, the interferometer receives light from the same strip across the pupil, and forms fringes as before. But knowing the actual wavefront distortions means that more powerful analysis methods will be possible. The process is known as Post-Detection Turbulence Compensation (Primot et al. 1990). In essence it is ‘software Adaptive Optics’ – i.e. instead of using the wavefront sensor signal to drive a deformable mirror, it is used in the data analysis. Compared with interferometry without the sensor, it will be possible to observe fainter objects, and obtain higher dynamic range. It will be possible to make observations of more complex objects (well-resolved stars and perhaps the brighter asteroids).

The new wavefront sensor was commissioned by Gordon Robertson, Andrew Jacob and John Barton during a session at the AAT from 3rd to 11th June this year. After setting up and testing the system, we made observations of stars in a short period of Director’s time on 10th June. The sensor is based on a microlens array (60×60 lenslets, each 0.4 mm square and with focal ratio f/130). A carefully arranged optical system selects one row of the lenslets and ensures they are illuminated by the same part of the pupil that will also go (via the beamsplitter) to the interferometer section. We thank the AAT site staff for their assistance with setting up for this run.

The run was very successful. John Barton has increased the speed of the CCD readout (vital for ‘freezing’ the atmospheric turbulence) and we can now obtain continuous readout of data frames from the

Figure 1. A small section of the wavefront sensor data from a run on α Ps Aus. Time increases vertically, and the data shown covers 2.5 sec. For clarity, the image has also been cropped horizontally, and only 27 of the 50 lenslets illuminated during this run are shown. The seeing was approximately 1 arcsec.
Thomson CCD at a period of just 10 ms, for sizes 523×15 (binned to 523×1) for the wavefront sensor, and 220×400 (binned to 220×1) for the fringe detector. The wavefront sensor data show the positions of the Shack-Hartmann spots in one dimension. As an example Figure 1 shows a small part of the data from one of the runs. Time increases vertically, and each lenslet leaves a wiggly ‘trail’, where the sideways fluctuations reveal the phase slopes across that lenslet, due to the atmosphere. It is clear that the 10 ms frame time is short enough to resolve the spot motion. In parts of the Figure correlated structures can be seen moving along the row of lenslets, as the wind blows turbulence cells across the telescope aperture.

We made tests on stars of various colours and magnitudes, at various ZDs etc. A test of deliberate telescope misfocus showed (as expected) that the wavefront sensor will readily pick this up, so another benefit will be in keeping the telescope focus optimised.

The next step in this project is to commission the full system, with the wavefront sensor and interferometer working together. This will take place in December, and will fully stretch the AAO’s CCD capability (with two

CCDs reading out together and in synchronism, at 10 ms per frame!)

References

AAT WEATHER PAGE
Steven Lee

To further the maxim that “everyone talks about the weather but nobody does anything about it”, I have created a “web weather page” which is linked (indirectly) to the control room met computer. This should enable more people to talk about the Siding Spring weather from greater distances and with even less hope of fixing it.

The page shows the current vital statistics such as temperature, wind, air pressure and rain, plus the last

Figure 1. Screen shot of the AAT weather page, showing the last 24 hours of meteorological conditions at the AAT. The plot shows the barometric pressure, wind speed and direction, and various temperatures.
Blue TTF Commissioning

Joss Bland-Hawthorn

The blue TTF (BTTF) arrived in April and appears to meet the design specifications. The BTTF complements the red TTF (RTTF) and extends the wavelength coverage for tunable imaging from 370 nm to 1 micron. The spectral properties were requested to match those of RTTF, i.e., resolving powers in the range 100 to 1000 over the 370 nm to 650 nm window.

The BTTF was commissioned (crudely) at the AAT in June and seemed to show a higher reflective finesse than the RTTF. This is borne out in Fig. 1 which was computed from data sheets supplied by Queensgate Instruments Ltd. The upper and lower curves show the expected range in resolving power available to the blue and red TTFs. If the post-coating plate flatness ($\lambda/130$) is the same for both TTFs, this could result in a slightly lower throughput for the blue TTF. The observing conditions were not good enough to confirm this. The TTF coatings are difficult and expensive to apply. The current BTTF coatings took at least two attempts to get this far. In principle, we could ask that the plates be recoated if potential users feel that the range in resolving power needs to be shifted downwards by a factor of two, say.

Note the diverging upper and lower envelopes in Fig. 1. We originally considered the idea of variable multilayer dielectrics to compensate for this, but it was considered too risky at the time. New Rugate coating techniques (Offer & Bland-Hawthorn, 1998, MNRAS) now make this possible. Rugate technology – and its potential applications for OH suppression, methane band separation, and “contrast imaging” – will be discussed in a future issue of the AAO newsletter.

For the BTTF, blocking filters for high-resolution work are on order from Barr Associates, Inc. Once again, the intermediate blocking filters mimic the characteristics of the RTTF filters. These blue filters are expected to be (central wavelength/bandpass) 390/18 nm, 440/20 nm, and 580/20 nm. The benefactors are (in order of declining munificence) the Goddard Space Flight Center, University of Cambridge, University of Sydney, Cavendish Laboratories, et l’Institut d’Astrophysique de Paris. Funds are currently limited for extending this set. Be aware that intermediate blocking filters much below 500 nm are very expensive to make.

Figure 1. The shaded regions show the expected range in resolving power available to the blue and red TTFs. The upper and lower envelopes are dictated by the TTF reflective coatings, the post-coating flatness, and the physical range of the plate spacings (2–12 mm).
As of 1998-B, an Iodine Absorption Cell will be available for use with the UCLES Spectrometer at the 3.9-m Anglo-Australian Telescope. The Iodine cell is used to provide a fiducial wavelength scale for making precise Doppler velocity measurements.

**Hardware**

The Iodine cell is mounted directly in the telescope beam, immediately behind the entrance slit of UCLES. The Iodine cell is a cylinder of pyrex, 10 cm by 5 cm, filled with 0.001 atmospheres of molecular I₂. The absorption cell is temperature stabilized at 50°C (± 0.1°C) with a temperature controller. The cell imprints a rich forest of molecular Iodine lines from 5000 Å to 6000 Å directly on the incident starlight.

**Observing with the Iodine cell**

The AAT staff can set up and align the iodine cell for use with UCLES. Once installed, the iodine cell can only be removed from the UCLES beam path by manual means. This requires the usual precautions over entry into the UCLES slit room.

**Data Reduction**

There are no standard (IRAF) packages for the analysis of spectra with embedded Iodine lines. Precision of 50 to 100 ms⁻¹ can be gotten from relatively simple cross correlation routines (Star shift – Iodine shift). Higher precision requires complex spectrometer modelling, using the embedded iodine lines to recover the spectrometer point-spread-function (PSF). Untreated, small changes in the PSF will lead to systematic velocity errors of 25 to 100 ms⁻¹.

The following three postscript papers outline reduction strategies that have been successfully used for Iodine data. The first paper discusses the use of iodine for variable star studies. Typically precision of 50 to 100 ms⁻¹ is sufficient for this work. The other two papers discuss full spectral modelling, which is required to achieve precision at the 3 to 5 ms⁻¹ level.

Further information can be obtained from Paul Butler (paul@aaoepp.aao.gov.au).


**FLAIR NEWS**

**Quentin Parker**

A new Z-drive has recently been commissioned with the FLAIR fibering system which has resulted in considerable time savings in moving fibres from ‘load’ to plate ‘height’ reducing this process per fibre from about 20 seconds to 3 seconds, or a saving of over half an hour for a typical field. Thanks to Ed Penny and Brendan Jones for sterling efforts in this regard.

The first magnetic fibre-button plateholder has also been undergoing tests on the telescope and was successfully used to observe a field of galaxies during the recent Proust et al cluster survey and for repeated spectroscopic observations of the new SuperNovae-Gamma ray burst event, where FLAIR is undertaking a regular spectroscopic monitoring programme. Repeated load and unload operations of the magnetic button plateholder in the telescope have not compromised the positional integrity of the buttons, giving confidence in the applicability of this technique for 6dF - the approved automated fibre-positioning system to replace FLAIR by mid 2000.

Once final modifications to the FLAIR magnetic buttons are completed as the final component of the FLAIR Interim Upgrade (this involves attaching metal fins to the tops of each magnetic button ferrule to alleviate some backlash residuals) the second FLAIR plateholder will be likewise modified. Both plateholders should be available with magnetic buttons from Semester 1999A.

**6DF NEWS**

**Fred Watson**

The 6dF project is under new management! At a 6dF engineering meeting early in July, project management formally transferred to Chris Evans. Chris is also Project Manager for OzPoz, and the new arrangement reflects the high degree of commonality between the two instruments. The new 6df project scientist is Fred Watson, taking over from Quentin Parker who will be returning to the UK at the end of the year. Fred and Quentin will be working closely together until Quentin leaves and it is hoped that Quentin can continue his close association with the project on his return to Edinburgh.

A number of strategic issues were discussed at the engineering meeting. Compromises between the engineering realities and the science drivers for the 6dF Galaxy Survey were explored in a presentation by Matthew Colless (ANU). An operational support perspective was presented by Chris McCowage and Ian Lewis. Other topics centred around the allocation of engineering resources for the project, and key players in the design include Stan Miziarski, Ken Russell and Lew Waller.

**"DEEP IMPACT": AN ASTRONOMER’S PERSPECTIVE**

**Ken Russell**

The movie “Deep Impact” is the latest and most professional attempt yet to portray the consequences of a Cometary Impact on the Earth. I went along to this movie with great expectations in the knowledge that the late Gene Shoemaker had been involved in consultations with them during the making of the movie. Gene would be regarded by most scientists involved in the work of identifying potentially hazardous asteroids as the person most responsible for highlighting the danger and no one understood the issues better than he did.

The initial discovery of the Comet by a young amateur was subsequently confirmed by a professional astronomer who was portrayed in a very unflattering manner… but I am sure he reminded me of someone I knew so I guess it could be accurate. So far this is pretty much the way comet discoveries go since few professionals actively look for comets in any structured manner. The time-scale is also close to what you would expect. Unlike Near-Earth-Asteroids which tend to be in fairly low eccentricity orbits Comets can come in from the distant Solar System without warning. The move from invisibility to discovery depends on the comet but it is rare that we get more than 2 years warning. The whole issue was kept secret by the politicians, something which I think would have been impossible if they hadn’t killed the professional astronomer off since we tend to be a fairly talkative lot and difficult to silence. It’s interesting that the public often asks me if we would publicise an event like this. I believe that despite the potential for panic, it would become public knowledge fairly quickly after it was confirmed.

A heroine with skin blemishes and a mother with wrinkles made me hope that this wasn’t going to be the typical American movie recipe. Morgan Freeman as the President gave a convincing performance and I almost started to believe we could mount a mission to deflect a comet in such a short time-scale. The arrival at the comet was spectacular but my doubts started to rise when I discovered that they intended to use penetrators… nuclear devices planted under the
surface. The general consensus these days is to go for blasts just above the surface to avoid fragmentation ... preferably many small explosions rather than one large one. Not surprisingly, they blew off a large fragment, about 2–3 kms in size, which remained on collision course with Earth. This size is well into the range for creating what we term an “Impact Winter” where so much dust is thrown into the stratosphere that sunlight is severely attenuated for a significant length of time and food production could stop for up to three years. This is also large enough to create a “Global Firestorm” where the molten ejecta from the impact is thrown into ballistic trajectories and on re-entering can raise the surface temperature to ignition point and above for up to 30 minutes. The movie ignored all of this but produced a very convincing tsunami, which is pretty much in line with what we would expect. I would call an impact like this a “Civilisation Ending Event” with half the population dying from the impact and two thirds of the survivors dying from subsequent starvation, however, such a scenario would have been too depressing I suppose so didn’t enter the plot.

The huge remaining chunk of comet would do the job in any case and it was at this point that they lost me. A last ditch effort with four nukes detonated in the heart of the comet blew it to smithereens and only a harmless but spectacular meteor shower ensued. Unfortunately that’s not what would have happened ... the fragmentation would not have been complete with many large fragments left intact and most of them remaining on course to impact the Earth. While we might have avoided another devastating tidal wave the impact energy would have been more or less the same but distributed over a much wider area. Agriculture would still have been compromised and species extinctions still a likely outcome.

But this was only a story and I think they did a pretty good job in producing a film with a message.

EPPING NEWS
Helen Woods

The AAO has continued throughout the quarter to recruit new staff to work on its external projects – IRIS 2 and OzPoz. In April we welcomed Brian Hingley who joined us to work as an electronics engineer on IRIS2. Dan Popovic and Hugh Stevenson also joined us recently to work as engineers on OzPoz. And Chris Evans has become the AAO’s projects manager. He has a long history of project management, some of it working on the refitting of warships – a suitable initiation for the astronomical challenges we will be able to offer him!

Chris Le Cornu, our accounts clerk for four years decided to take up the offer of a position in Gosford, an hour or so north of Epping where she has lived (and commuted) for some time. Her replacement is Devika Hewa, who brings plenty of accounting experience with her.

EPPING ON THE MOVE!
Joan Wilcox

Well, not literally, but there is a lot of change going on. There have been several new recruits over the last few months to work on IRIS2 and OzPoz. The tables outside are crowded at morning tea, the benches are collapsing under the weight, and we scan the horizon daily for a sighting of Wayne Clarke bringing down from Siding Spring the new benches the AAT team has made for Epping.

We needed to undertake some hefty renovations to accommodate our new staff. An early priority was to bring back into use the offices in the Melocco Building that housed cardboard boxes and old computers. Lew Waller made us an offer we couldn’t refuse: if we built him a new shed, he would use that for storage AND he would get rid of a lot of the old stuff. Before he could change his mind, the skip was there and the clear out began.

At the same time, Lew was overseeing the recabling of Epping (an unrelated project, but contributing wonderfully to the general mayhem) and the basement was being reconfigured to accommodate four extra staff.

The old chart room and the PDS machine accommodated highly desirable space but were hardly ever used. The PDS machine and some photographic plates have gone to their new home in Melbourne, the rest into a smaller, newly built room in the Massey Building. Shortly, three smart new offices and a software development laboratory will rise from the ashes and Tony Farrell will finally get a room with a window.

The Observatory’s wildlife has also been busy. One of the tawny frogmouths perched on a branch outside Helen Wood’s office for a day. We don’t know whether it was one of last year’s parents or one of the offspring but it was a happy sighting. This morning at tea we watched the comings and goings of a pair of rainbow lorikeets who have nested in the tree the tawny frogmouths used last year.
The AAO librarian has recently been on the move again. While accompanying her husband to the US, she took the opportunity to visit the libraries at NASA Goddard Space Flight Center and the US Naval Observatory. Both of these libraries were fascinating places to visit — NASA is an enormous place by our standards and has the largest special library I have ever come across. The USNO library is on a much smaller scale, beautifully situated on a hill to the north of Washington and with wonderful views of the city from the dome of the telescope. I was made very welcome by the librarians in both places who were kind enough to spare time for a visiting librarian.

On the Epping front, the AAO library in June hosted a meeting of astronomy librarians from CSIRO, Mt Stromlo, Sydney University and the Australian Defence Force Academy. We heard from Jeanette Regan (Mount Stromlo) about the LISA 3 conference in Tenerife in April, and discussed library matters such as metadata and journal cancellations.

Replacing the large and unwieldy list of books there is now a search engine for the AAO’s monograph collection on our web site at http://www.aao.gov.au/library/libsearch.html. For those library users actually in the library it is vastly more user-friendly than CAIRS, if less sophisticated. Please try it out and let the librarian know of any improvements you think could be made (lib@aaoepp.aao.gov.au).

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LETTER FROM COONABARABRAN
Rhonda Martin

It snowed three weeks ago – then it blew a full gale – naturally enough, 2dF was on the telescope. Branches were torn from trees or were left hanging by a thread, waiting for some unwary tourist to walk below. The path up to the AAT had to be closed when it was discovered that far too many people were having fun sliding down the slope on the seats of their pants. Some even slid over the edge of the mountain into the National Park and were never seen again!

Because it snows so rarely at Siding Spring, we tend to wax lyrical about it — or rather, I do — it’s a different matter for the technicians struggling in the dome with the air temperature at point six of a degree and their fingers rapidly turning blue, their breath turning to solid chunks of ice which they cannot let fall on the primary mirror.

It’s the time of year when the Anglo part of the Anglo-Australian Observatory feel nostalgic and there is a spate of Christmas in July parties when they wear funny hats and waste perfectly good brandy by burning it on a pudding. It’s the time of year when it is usually clear and cold with superb seeing, but not this year. This year it has been miserable, cold and even worse – cloudy. We have been told that this has all been caused by the little sister of El Niño, whose name must be Chaos.

One distinguished visitor to the mountain was the Minister for Science who arrived in a jet, a sight not often seen at Coonabarabran airport. It was a beautiful aircraft and we three drivers who drove the entourage to the airport just, sort of, well, hung around to see it take off and there was perhaps a sneaking doubt that the strip would be long enough, but of course, it was — just! There was also the sheer jealousy that beardless boys could fly this thing of beauty, and we couldn’t!

We must welcome Robert Patterson to the AAO — Robert is our newest electronics technician and like our other Robert (surname Dean) is tall and lean so quite often, when one calls out for Robert, one gets two for the price of one.

Almost imperceptibly, the days are getting longer, and soon we will all be moaning about the heat. 2dF is working well, even if it does tend to bring foul weather in its train. Perhaps we could rent it out as a drought-breaker!
CROSSWORD COMPETITION

We are pleased to announce that the winner of the crossword competition in the April issue of the newsletter is Peter Browne, from Macquarie University in Sydney. Peter wins a David Malin photograph of his choice.

Thanks are due to all those who entered the competition, and we hope that there will perhaps be another one in the next issue.

The solution is printed below.

PROJECT MANAGEMENT

Chris Evans

They asked me to help fill a space in the Newsletter – I suppose I should decide what the goal really is before embarking on this course of action – but then that takes all the fun out of it doesn’t it?

Well I have been at the AAO now since early May. My role is to introduce Project Management and to get the major projects under control.

When you start a project it’s a good idea to have a clear picture in your mind of what you are trying to achieve – “If you don’t know where you are going any road will take you there”. The problem with our projects is that all too often our reach exceeds our grasp. The capacity of the scientist knows no bounds in terms of reaching for new scientific goals and the technical and engineering staff often have to move into uncharted territory to achieve the goal.

It is understandable that some might ask – “How do we define the technical objectives and then mobilise a diverse group of people to work in harmony to achieve the vaguely defined goal at some arbitrary date in the future without sufficient funds to pay for the work?” Clearly you don’t!

The challenge is to capture the technical objective and put this into some measurable description as a scope of work. For our own internal projects it is important to seek input from the end users of the instrument to get practical input to the design and embrace the need to get the instrument up and running and minimise technical down time. Some additional cost in design often reduces manufacturing costs and if the correct critique and input is achieved early should result in a more robust and reliable instrument.

Our aim then is to prepare a plan that breaks down the work into the component tasks and assigns these to people who have the skill and the time to do what is needed in the order required to reach the goal in the time required. I have never worked in any organisation where people had the time to do what is required of them – I am regularly told this is the case here – so all’s well so far. It’s clear however that time and costs are constraints in terms of project objectives and must be reflected in the master plan.

The trick in this business is not to get too despondent when you realise that you can’t see clearly what has to be done down the track. As drivers we set off not knowing what is around the corner but we have enough control and skill to avoid crisis. We do need to know the rules of the road and have above all some discipline and confidence that the others around us will perform in a predictable manner.

By incorporating the best local knowledge we have into our schedules and scope of work we can get together the basis of a plan which has to be updated regularly with cost and progress data. These are the measures by which we manage. Every so often we review our plan concentrating on the immediate period ahead of us to put all the current knowledge and experience gained so far into the plan for the next 4 to 6 months – the so called rolling wave approach.
Image of NGC6357 (17 24 42, -34 13 23 J2000) an active star forming region. The image is 10x10 arcminutes in size with NE to top left hand corner. The data are from SuperCOSMOS 10 micron mapping mode scans of an early 3 hour UKST Tech Pan H-alpha exposure on standard survey field 392. The image was produced as part of the thesis work of John Precious at the University of Bristol under the supervision of Dr. S. Phillipps (co survey P.I. with Dr. Q. A. Parker, AAO).