# ATNF News

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## FEATURES IN THIS ISSUE



# A "new" spiral arm for the Milky Way?

*N. M. McClure-Griffiths, J. M. Dickey, B. M. Gaensler & A. J. Green*

The structure of the outer disk of the Milky Way has long been a mystery to Galactic astronomers. Though we know that the neutral hydrogen (HI) disk extends far beyond the stellar disk, we know very little about its structure in this Galactic "outback". In particular, we do not know how far the HI spiral structure of the Galaxy extends.

As part of the Southern Galactic Plane Survey (SGPS; McClure-Griffiths et al. 2001) we have recently identified a remarkable structure in the far outer disk of the southern Milky Way. This structure, shown near the top of Figure 1, is a ridge of emission lying at the far positive-velocity edge of the SGPS longitude-velocity (*l*-*v*) diagram. The *l*-*v* diagram shows HI emission in the Galactic mid-plane ($b = 0°$). Emission at negative velocities is interior to the solar circle and corresponds to gas at two distances, whereas emission at positive velocities lies exterior to the solar circle and generally corresponds to only one distance with larger velocities at larger distances. The new ridge of emission arcs from $l = 253°$, $v = 102$ km $s^{-1}$ through $l = 299°$, $v = 110$ km $s^{-1}$ to $l = 321°$, $v = 88$ km $s^{-1}$. It is relatively cohesive across more than 70 degrees on the sky, kinematically distinct from its surroundings, and is notably the last feature before the edge of the Galactic disk. Overlaid on Figure 1 are lines of

Continued on page 20

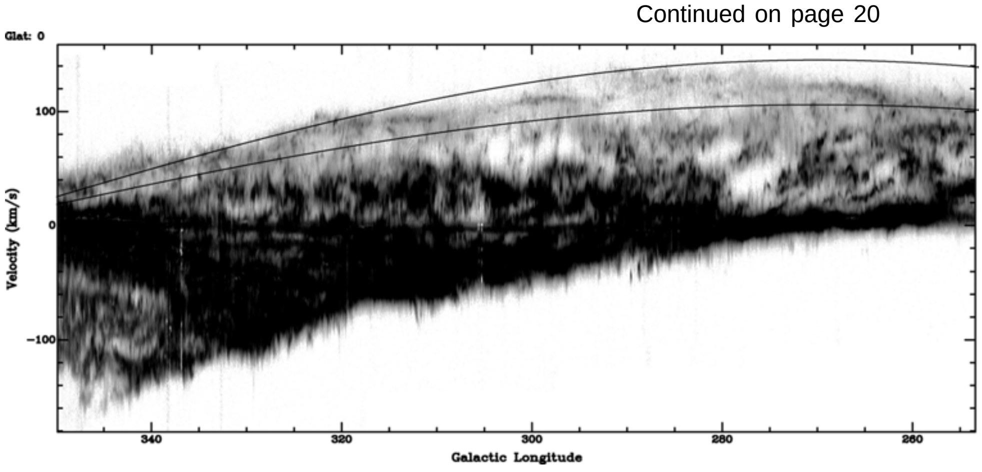


**Figure 1: HI longitude-velocity (*l*-*v*) diagram of the Southern Galactic Plane showing the outer arm. The arm is observed as a ridge of emission at the most extreme positive velocities. The image has an angular resolution of 2 arcmin, a spectral resolution of 0.8 km $s^{-1}$, and uses a square-root transfer function from 1 to 70 K. The solid lines are at constant Galactocentric radii of 16 and 24 kpc. (From McClure-Griffiths et al. 2004).**

# Editorial

Welcome to the June 2004 ATNF newsletter.

For this issue we have made a special effort to streamline the article submission process and towards this goal we sent out a guidelines section in our call for article contributions. Our thanks and appreciation to all for your help and cooperation. The guidelines for contributors have been placed on the web at *www.atnf.csiro.au/news/newsletter/ guidelines.html*.

In our cover page article in this issue Naomi McClure-Griffiths describes the discovery of a "new" spiral arm for our Galaxy, an outcome of the Southern Galactic Plane Survey carried out by her with the Compact Array and Parkes radio telescope. On page 16 first results from a systematic search for OH megamasers in high IR-luminosity galaxies are described, a project putting to good use the unique capabilities of the Compact Array. We bring you news on several other developments, in particular the useful Seeing Monitor that was recently commissioned at the Compact Array, the laudable work on the outreach front and the soon-to-be-released utility, the Remote Visualisation System, a project for the Australian Virtual Observatory.

We have an obituary on Bob Duncan, ATNF astronomer, whose sudden passing was a shock to all who knew him. We are happy to have had the opportunity to present his most recent work in this newsletter – just an issue ago.

We are always happy to receive your contributions. Your suggestions and comments on the newsletter are welcome! You can contact us at *newsletter@atnf.csiro.au.* The web version of current and previous newsletters can be found at *www.atnf.csiro.au/news/newsletter.*

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# From the Director

At the start of 2004, the Prime Minister's Science and Engineering Innovation Council (PMSEIC) convened a small working-group of scientists and engineers, chaired by Martin Cole, to prepare a report on Australian astronomy. The working group's brief was to provide a stocktake of Australian astronomy's capabilities, the impacts on, and benefits to, Australian society and possible future priorities. The report was presented to PMSEIC on 17 June and is now publicly available. As a member of the working group, I was both delighted and privileged to have the opportunity to present the ongoing success story of "Astronomy Australia" at the highest level within the Commonwealth Government.

The report emphasised the cohesiveness of Australian astronomy, from its scientific success to its technology impact both within the research sector (through astronomical instrumentation) and beyond. Astronomy's role in inspiring young people to study science and engineering was also highlighted. Finally, some of the bold visions for the future of Australian astronomy were enunciated, including participation in the Square Kilometre Array (SKA) and optical/IR Extremely Large Telescope (ELT) projects.

As part of "walking the talk" it is reassuring to note just how many aspects addressed in the PMSEIC report also feature in this newsletter via examples of recent ATNF science/engineering and outreach highlights. Scientific impact is exemplified by the discovery of a "new" spiral arm for the Milky Way, while the successful commissioning of the ALFA receiver again underscores the world-class engineering capabilities within the Australian astronomy sector. The success of the workshop for school teachers and the new outreach/education website demonstrate the ATNF's ongoing commitment to developing and implementing strategies that will maximise astronomy's impact in the classroom.

ATNF also remains committed to maximising Australia's engagement in the international SKA program through its Major National Research Facility (MNRF) funded projects. In this newsletter we report on the decision to halt the development work on Luneburg lenses as an SKA prototype and on plans to re-focus the New Technology Demonstrator (NTD) as a low-frequency prototype array at the representative Australian SKA candidate site in Mileura, Western Australia. For the coming nine months, the short-term goal in the NTD program is to complete a preliminary evaluation of the technologies in the concentrator/focal-plane-array space, with a view to taking forward the most effective technology to prototype development, and MNRF project completion in mid-2007.

At their recent meeting, the AT Users' Committee strongly supported this proposed outline plan for the NTD. Together with the Compact Array broadband upgrade, ATUC endorsed that the highest priority at the ATNF be given to these MNRF programs over the next two to three years, in line with similar recommendations made by the Steering Committee in April. This strong alignment of ATNF's stakeholders in a shared vision for the future of radio astronomy, coupled with the success of the more broadly-based PMSEIC report, augers well for the development over the coming year of a decadal plan for Australian astronomy in 2006 – 2015.

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# Bob Duncan: 1929 – 2004

Former ATNF staff member Bob Duncan died unexpectedly on 19 April, while bushwalking in Western Australia. He was 74.

Bob had retired from the ATNF in 1994, but continued to use the Compact Array in his long-term pursuit of the mysteries of Eta Carinae, and for other work. The October 2003 issue of this newsletter carried an article in which he and his collaborators summarised their work to date on Eta Carinae, work that he had begun in 1992, while in the February 2004 issue he wrote about the Compact Array imaging of the G2.4+1.4 nebula and the associated Wolf-Rayet star WR 102. Bob was enjoying research as much as ever: as he had noted at his retirement party, it was "addictive".

Shortly before he retired, Bob spent more than 600 hours during 1990 – 1992 observing with the Compact Array, to find and monitor flux, phase and polarisation calibrators, creating a solid foundation for the present calibration lists. As a frequent observer, Bob thought it worthwhile to summarise useful snippets of observing information into a couple of pages, creating a guide much appreciated by all observers.

Bob's membership of the ATNF Astrophysics group was just the last chapter in his working life, which had had many changes of direction.

Born in Adelaide, he became hooked on science by the age of six when, he recalled, he was "given and avidly read and memorised the 10 volumes of Arthur Mee's Children's Encyclopedia". He started working at the age of 15, as a technician in the South Australian Institute of Medical and Veterinary Science. At the time this was the only medical laboratory in South Australia. As well as performing a range of biochemical analyses, Bob also had to dose elderly patients in the hospital wards with vitamin-C. These patients were mainly elderly ladies suffering partial blindness from scurvy, brought about by subsisting largely on tea and biscuits. The doses of vitamin-C Bob was supposed to administer were low, and took months to combat the disease. He therefore started – "after consultation with my more senior colleagues" – upping the dose quite drastically. "It certainly speeded the old ladies' recovery, and more importantly to me, reduced my workload," he recalled.

Bob wanted to enter university as soon as he was old enough. But he was diverted from the path of medical science by reading the set text in Physics for the University of Adelaide entrance exam. "Anyone could sit for any exam if they paid their money," Bob remembered. He sat the exam and topped it.

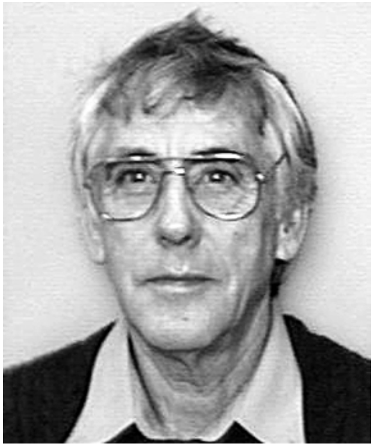
Photo: © CSIRO

Bob Duncan

Once at university, Bob found his studies left him with ample time to plan a series of pranks and hoaxes. The most notorious of these made front-page news in Adelaide. On the morning of 25 November 1952, the University awoke to find a set of yellow footprints, each almost a metre in size, leading from the house of the Vice-Chancellor, A. P. Rowe, through a car park, and then on again to Elder Conservatorium, where they went up the side of the building. Lashed to the lightning rod on the topmost spire, more than 30 m above the ground, was a female dummy. At 9.30 am, when a crowd had gathered to gawp at this, a huge flag bearing the skull and cross-bones ran up the flagpole on the nearby Bonython Hall. Officials assumed that the students responsible were in the Bonython Hall and ran to catch them, but the door was locked and jammed – and when finally opened, it revealed a clockwork mechanism that had been set to raise the flag. Mindful of repercussions, Bob and his two co-conspirators told nobody of their part in the prank and kept no records, not even newspaper cuttings. Only when he was retiring from CSIRO did Bob publicly confess, for the first time, to being involved.

At the end of his university studies Bob applied for a teaching position at the University of New England. But his professor at Adelaide, Leonard Huxley, told him firmly that he "was not a suitable person to teach students", and that he would not get the New England job. It appears that Huxley arranged for Bob to join CSIRO: Bob did not apply for a job, but "[Huxley] waved a piece of paper in front of my nose and I signed it," Bob recalled.

His first CSIRO position, in 1953, was working with the Radio Research Board under D. F. Martyn, who had been the first Chief of the CSIRO Division of Radiophysics. The relationship between Martyn and his successor at Radiophysics, Taffy Bowen, was less than cordial, and Bob was caught up in their rancour. Bowen had become enthusiastic about the prospects of using cloud-seeding to boost rainfall, and was running cloud-seeding program at Radiophysics. Martyn asked Bob to look into the statistical analysis of these experiments. After looking at the results, Bob concluded that they didn't support Bowen's faith in cloud-seeding. Bowen was not impressed – and this later affected Bob's career.

Bob was then asked to look into another "crazy" idea that was being pushed within Radiophysics: that Io, one of Jupiter's moons, was affecting the bursts of decametric radio emission from Jupiter. In this case, Bob found that the evidence supported such a claim. Further analysing the data, he concluded that, contrary to previous belief, Jupiter had a well defined, constant, rotation period. Bob was eventually vindicated and his period for Jupiter's rotation was adopted by the International Astronomical Union.

In 1970 D. F. Martyn shot himself, and his research group was disbanded. With his interest in Jupiter and other topics in radio astronomy, Bob wanted to transfer to Radiophysics. Unsurprisingly, Taffy Bowen was not welcoming, and Bob instead moved to the CSIRO Division of Mathematics and Statistics (DMS) in Adelaide. While there he applied statistical techniques to the taxonomy of rats, showing that there were serious errors in the traditional classification. The head of his division thought that this was going too far, and suppressed the publication.

In 1973 Paul Wild replaced Taffy Bowen, and Bob finally moved to Radiophysics; initially as part of DMS but later as a member of the solar group that used the Culgoora radioheliograph. In 1979 he proposed wave-ducting of solar radio-emission as an explanation of a number of solar phenomena. The radioheliograph was closed in 1989, and Bob changed direction yet again, transferring to the ATNF's Astrophysics group.

"In a conventional sense these changes have been detrimental to my career," Bob said, "because with each change of discipline I restarted as a novice, at the very least have been perceived as a novice. In subsequent fields I have never been as productive as I was in my first field, ionospheric physics. Nonetheless I certainly do not regret the changes; they have widened my knowledge."

Bob's enthusiasm for science did not slacken in retirement. Nor did his enthusiasm for life. He was a long-term member of the Willoughby Symphony Choir, even taking on the onerous job of looking after the choir's music collection: he'd regularly announce forthcoming performances to colleagues at the Radiophysics Lab (and remind them he could get them discounted tickets). He was an active bushwalker, as he had been for fifty years, frequently returning from Western Australia or Kakadu or elsewhere, full of enthusiasm for his latest trip. And he even took up figure-skating (to the concern of his wife, Rosslyn), and could be seen joyfully twirling on the Macquarie Centre ice-rink in Sydney.

Persistent, forthright, with a healthy scepticism and a sense of humour that was not always obvious on the surface, Bob will be warmly remembered by his colleagues. His name is on the observations of Eta Carinae scheduled for the Compact Array in July. "Bob wanted to do this project, lead it, and be there for the observing," said Baerbel Koribalski, one of his co-observers. "We hope he's still going to come – in some form."

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Stephen White, one of Bob's recent collaborators adds:

I first met Bob when I was a graduate student and Bob was a member of the famous solar radio group at CSIRO. He was already well-known for his explanation of why low-frequency solar radio bursts appeared to come from heights that were much larger than their true heights, an explanation that still stands after 25 years. We didn't start working together until I had been at Maryland for a long time and was looking for an Australian collaborator to work on observations of the famous southern star, Eta Carinae. After the closing of the radio-heliograph at Culgoora, Bob made the transition to stellar radio astronomy comfortably thanks to his strong physics background. I remember our joint astonishment when, the second time we observed it, we found that Eta Carinae had brightened so much that it had become one of the brightest radio stars in the sky. It was Bob who came up with the "lighthouse" explanation for the brightening that is now commonly accepted. That discovery and those that followed pushed Bob into prominence within the community of astronomers working on massive stars, and many of Bob's colleagues in that community have passed on their sorrow at Bob's loss. It was always a pleasure to observe with Bob, and particularly going to Culgoora with him where his knowledge of the local bush and his stories of the old days at Culgoora made him a great companion. I admired his dedication to bushwalking after his retirement, and the one comfort we have is that he died while doing something he truly enjoyed. I shall miss him.

# The ALFA story

Puerto Rico. Ahhh it conjures up the sweet breezes of the Caribbean wafting over white sand beaches, kicking back and sampling as much of the local rum needed to make you sound Spanish even though you are talking Australian English. Well, wake up because where we are going now isn't like that at all! This is commissioning a seven-beam receiver at an observatory in the middle of a karst area topped with jungle where saying CSIRO as in "sigh-ro" sounds too much like the Spanish "cero" meaning "zero" so when people ask who you work for you are telling them you work for "nothing".

Let's get the stress levels up a bit here with an inflexible delivery and installation date, working with a webcam trained on you, a month feeling confined to barracks (nice barracks though), the uncertainty of how the equipment would perform niggling in the back of your mind and having "office" space sited in an area equivalent to setting up a desk in the foyer at Parkes or Narrabri. A double-edged sword really because it was distracting to acknowledge the multitudes that walked through an area that was access to the control-room, the candy-bar, the receiver back-end room and the route for workers on their way to the telescope but at the same time it made sure that we mixed with the staff, whether we wanted to or not, and became more a part of the furniture rather than just commissioning engineers tucked away in our own compound.

Photo: Graeme Carrad

Figure 1: Looking little while lifted.

Pat Sykes, a most worthy and reliable travelling companion, and I spent a month at the Arecibo Observatory and from the first day it was "game on". Many staff were very excited about the new equipment arriving, the so-called ALFA receiver. Some staff weren't so excited as the observatory is home to three different disciplines and this delivery was getting in the way of real science. And then there were the "riggers" who look after the massive structure and they have different ideas about handling scientific instruments and whether the science or the structure is the main raison d'etre for this big bowl in a limestone sinkhole. But the receiver hadn't even arrived on site and it took quite some phone calls and persistence to get the three large, heavy boxes through customs and to the site. Despite the sagacious shaking of heads and pessimistic predictions it turned up on 1 April (no joke) as planned. Well…right at lunchtime so the planning wasn't that good.

After preparing and cleaning our assigned "lab" space, which looked like a large indoor loading area, Pat and I unpacked, sorted, instructed and documented the disassembly of the receiver to let the people see the innards. They could only oooh and ahhh at the shiny splendour that was revealed. There was instruction in maintenance, assembly and operation to deliver, modifications needing to be made driven by the need to interface our gear with their telescope, while Pat gave invaluable tuition in cryogenic techniques and practices. The need to complete documentation forced us to work many late night and weekend sessions in the relative calm after staff had gone home. Then we wrestled with contaminated cryogenics before testing in the "lab". When the Arecibo staff were happy with that testing, ALFA got lifted to the Gregorian dome of the telescope and was tested again and there it sits now gathering data. The plush toy kangaroo that accompanied the receiver in transit still sits with it and may well for all time. The workers adopted it as a lucky charm.

Photo: Graeme Carrad

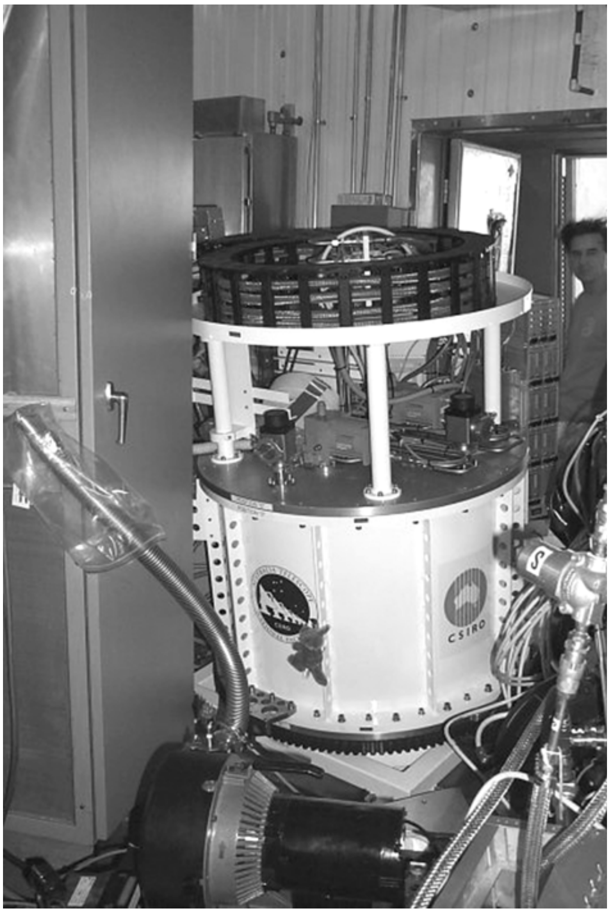


**Figure 2: In place and happy.**

The lift day and the days leading to it were nervous and had people re-checking calculations of lift stresses as well as desperately finishing work in the dome. Rain on the day would force a postponement. An early start was demanded to avoid the winds that can develop later in the day (they didn't) so at 4.30 am we rolled up and after some preparations took the receiver in darkness to the lift area at the bottom of the "bowl". The early morning mist, the long cable dangling and the pre-dawn single-file motorcade with headlights ablaze that eventuated gave the event the ambience of a sunrise, hanging-style execution. A front-end loader rolled in front of the site truck that carried Pat and the receiver. This truck looked akin to one straight out of the "Greenacres" prop warehouse. The loader was to provide protection in the case of brake failure on a steep slope! The receiver that had seemed large in the lab looked diminutive near the dome and only Pat Sykes can describe the overcrowded chaos of the receiver room when riggers, their supervisor, receiver staff, a film cameraman, a stills cameraman, an OH&S rep and other onlookers packed the limited space during the final fitting. I watched on CCTV in the relative comfort of the control room, in between loading ancillary equipment into the truck for the following lifts, happy to be me and not Pat.

A month seems a long time, and certainly the ALFA staff were taken aback when we first suggested that we would stay that length of time, but that was how long it took to go through all the procedures and more time could have been usefully occupied. We worked closely with people whose English was better than our Spanish and were exposed to the many different personalities that make up the place. We appreciated the generosity and warm friendship that those forming the tapestry of countries represented at the observatory extended to us.

Early results have been encouraging and they really got more than their money's worth as they have discovered the receiver can be used at frequencies higher than those specified (1225 – 1525 MHz ) in the contract so observations at the 1665-MHz spectral line of OH can be made and who can honestly say that that thought doesn't set their spine a-tinglin'.

So Arecibo seems happy and Pat and I have had an "experience" which will last long in our memories and part of the memory will be the forty or so people at the ATNF sites that contributed their ideas, advice and expertise to make the instrument what it is – so a big thanks for your contributions.

ALFA news is at *http://alfa.naic.edu.*

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# Narrabri atmospheric seeing monitor

In time for the start of the new millimetre observing season with the Compact Array's new 3-mm receiver systems the Narrabri atmospheric seeing monitor (ASM) has commenced operation. In future it will be the prime tool to monitor the atmospheric phase stability for the array. Based on its output, observers will be able to assess shortly before the start of their scheduled observing runs whether 3- or 12-mm observations will be carried out or whether instead to conduct a centimetre swap program.

Test operation of the ASM started in early May 2004. Since then Narrabri staff have been using the data received from the ASM to optimise its operation and its software interface, including a GUI that allows the user to configure his or her own display options when accessing the ASM database. The ASM database stores all data since its inception for later use. Entries describing the atmosphericphase stability will also be entered into the Compact Array data-files in future.

The ASM comprises two reinforced commercial 1.8-m parabolic dishes near two of the Compact Array's base stations (W113 and W128, respectively), with a baseline of about 230 m. It operates at a frequency of 30 GHz, making use of a 30-GHz beacon signal emitted by the Optus-B3 communications satellite. The two parabolic dishes are fixed in a position to point towards Optus-B3 (at an elevation of about 54 degrees). Each station of the ASM has its own electronics to down-convert the radio signal to an intermediate frequency (IF) of 240 MHz, which is transported to a lockin amplifier in the Narrabri screened room (the "correlator room") via optical fibres.

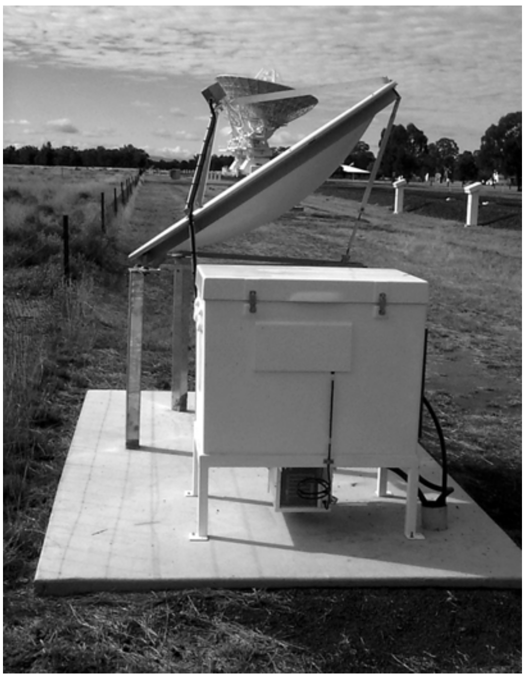


**Figure 1: The western station of the ASM, with its eastern counterpart visible in the background.**

The hardware of each station of the ASM is contained in insulated, air-conditioned cooling boxes, which protect the equipment against external influences (heat, moisture, galahs, kangaroos, human intervention). At the same time, the boxes are radio-tight to avoid causing radio frequency interference. Figure 1 shows the western station of the ASM, with its eastern counterpart visible in the background.

The lockin amplifier and associated electronics are kept in one rack in the screened room, which can be moved or reconfigured for use in telescope holography (from which the hardware was originally adapted). The phase monitor is controlled from a PC running Linux. New monitoring software reads the ASM data from the PC, archives it, and makes it available to client PCs for display. Via a TCP/IP interface a second PC is connected to the data stream for monitoring, maintenance and system re-configuration from the Electronics Lab.

Once phase-locked, the output of one antenna is used as reference, while the relative phase of the output from the second dish is measured against this reference. The phase noise of one incoming signal compared to the other is a measure of the atmospheric stability over the 230-m baseline spanned by the phase monitor. An example is presented in Figure 2, where phase noise measured by the ASM over a timespan of five days, from 9 – 14 May 2004, is compared with contemporaneous measurements from a 153-m baseline of the Compact Array. The plot shows a good general correspondence. For astronomical use the measured phase noise, which is averaged over a few minutes, typically, is converted into an rms pathlength-noise, as displayed in Figure 2.

Optus provides us with an accurate prediction of the satellite position from which we can predict the phase – top panel, Figure 3. This allows us to correct for the satellite diurnal motion, which produces the turns of phase, as shown in the second panel of Figure 3. The difference, in the third panel, provides a clear picture of the atmospheric contribution to the phase. The online processing currently tracks the rms of two-point differences.

Final testing and fine-tuning of the system is underway and observers can expect to have the seeing monitor available during their upcoming millimetre observations.

Congratulations and thanks to the Narrabri and Marsfield teams for their successful completion of the project. In particular, credit goes to G. Graves, B. Parsons, M. Kesteven (Marsfield), R. Behrendt, D. Brodrick, B. Hiscock, C. Leven, J. McFee, S. Munting, C. Murphy, B. Reddall and B. Tough.

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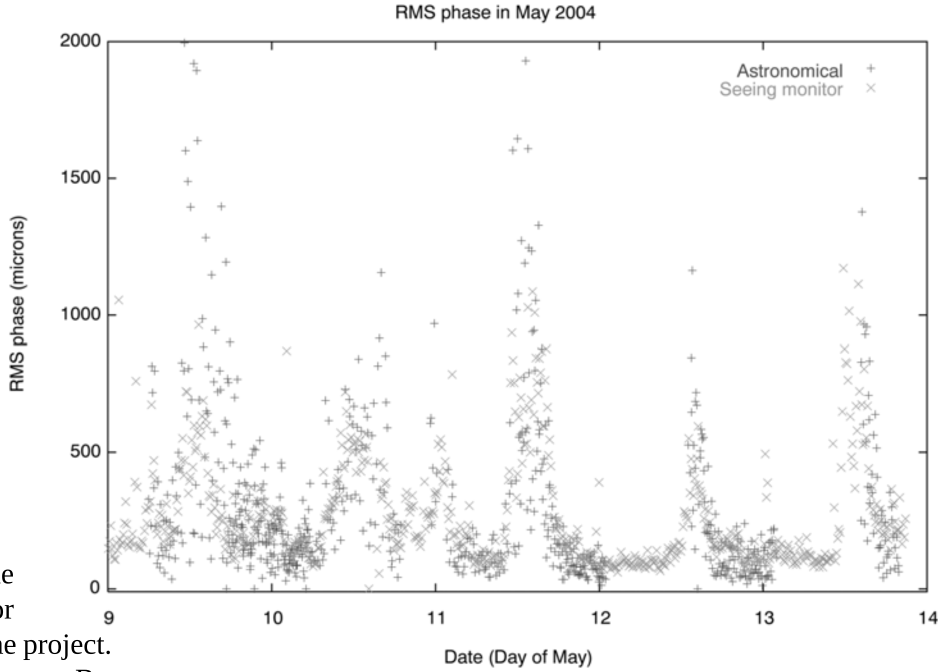


**Figure 2: Phase noise measured by the ASM compared with phase noise over 153-m Compact Array baseline.**

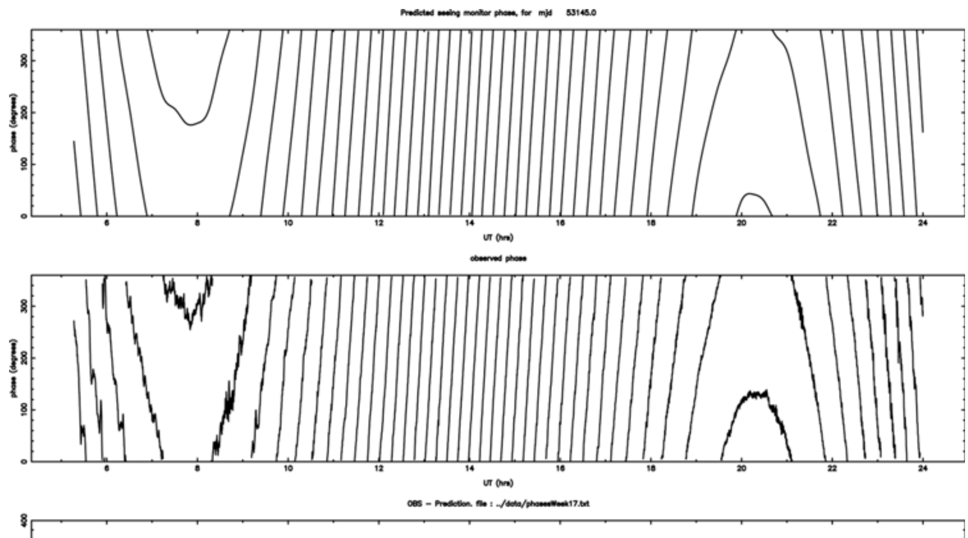

**Figure 3: Top panel – predicted phase. Middle panel – observed phase. Bottom panel shows the atmospheric contribution to the phase, obtained as difference between observed and predicted phase.**

# Remote visualisation service

The ATNF has recently increased its efforts in the Australian Virtual Observatory (Aus-VO). One of our VO projects in progress is a remote processing infrastructure. The Remote Visualisation System (RVS) is the first application that is being developed to make use of this infrastructure. The RVS is a distributed software system that allows visualisation and analysis of astronomical images that are located in remote archives. It is a server-side system where all of the image processing is done on the RVS server. The client merely displays the result to the user. This is different to the client-side processing model that is commonly employed in astronomy. Aladin *(http://aladin.u-strasbg.fr)* is an example of a client-side visualisation system.

The RVS can be used to view any astronomical (FITS) image that is accessible via a URL. Its server-side model means users are not required to download images they wish to view to their local computers. The processing is done on the RVS server and only the rendered result is then sent to the client, i.e. the user's computer. The server provides its functions via a web service by using SOAP as its communication protocol. Delivering content via a web service consequently results in a greater number of ways in which the RVS can be used. Client software applications are no longer required to perform sophisticated image-processing in order to achieve visualisation functionality. Instead, the application may use the services provided by the RVS web-service. This makes possible a variety of different user interface types for end users. Web browsers, Java applets and stand-alone applications can all be used to visualise astronomical images via the RVS.

The RVS demo client is an example of a client application developed to demonstrate some of the capabilities of the RVS server. The client is a Java application that is launched by clicking on a link inside a Java-enabled web browser. For example, a user submits a query for an image, the result of which is a cube. By clicking on a "View with RVS" link, the user will launch the Java application with the FITS image loaded for viewing instead of downloading the image and using their local package to view it.

The user can then view and analyse the image using the functions provided by the RVS. Some of these functions include position tracking, zooming, enable/disable axis labels, viewing any channel/plane in a cube, selecting from a pre-defined list of colour maps, defining minimum/maximum data range for images, overlaying of other images as contours and defining contour levels.

Although not implemented in the demo client, the RVS server also supports the sharing of a session between multiple users and the drawing of annotations on the canvas. The RVS' core

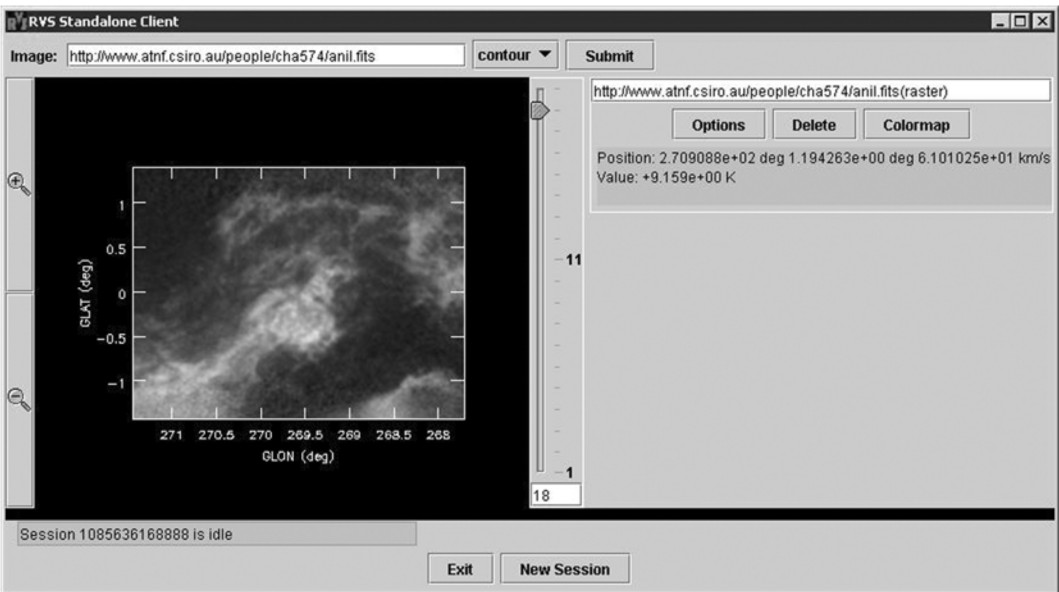


Photo: Anil Chandra and Naomi McClure-Griffiths

**Figure 1: A screen-shot of the RVS demo client being used to view an image obtained from ATNF's Southern Galactic Plane Survey (SGPS).**

visualisation functionality is provided by the aips++ display library. As a result, users can access many of the image options that are available in the aips++ viewer.

The RVS addresses the need for quick visualisation and analysis of large astronomical images stored in remote locations. In cases where images are hundreds of megabytes in size, a high-bandwidth connection between the RVS server and the data archive will result in a much faster transfer of data than if the users downloaded the image to their local computers. This factor alone makes the RVS a useful tool in the virtual observatory where images will often be produced as a result of a set of queries and operations on data that is located elsewhere. The server-side model employed by RVS has inherent disadvantages, one of which is slower interactivity. Since all operations require communication with the remote server users will not experience the instantaneous response times they may be familiar with. Even simple operations such as position tracking require remote communication, which although is done quickly enough, the performance is not quite as good as the performance offered by client-side packages.

In the next two months, we are hoping to deploy the RVS at ATNF. After performing queries on ATNF data archives, users will be able to quickly visualise the resulting FITS images using RVS. We will eventually make the RVS source publicly available so the system may be deployed elsewhere or be used in other projects.

Access to the RVS demo is currently restricted to a small group of users as it is undergoing testing and ongoing development. If you would like to know more about the RVS or would like to get access to the demo, feel free to contact me. I appreciate all the feedback I get.

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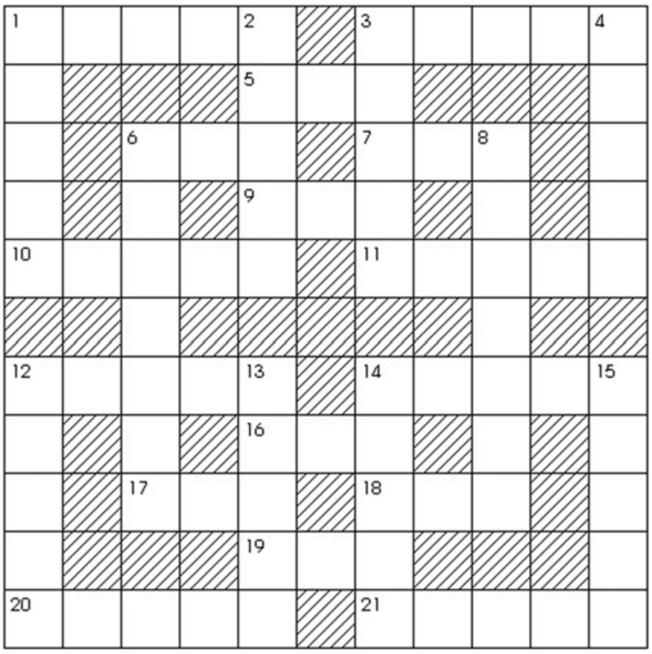
# ATNF crossword




**ACROSS**

1. American radioastronomy pioneer (5)
3. Early Australian radioastronomer (5)
5. Anglo-Australian Observatory (3)
6. Former ApJ editor (and Minor Planet 9423) (3)
7. Greek god of shepherds (and MP 4450) (3)
9. To ___ is human (3)
10. Radio astronomical valley in California (5)
11. The colour of Australian skies? (5)
12. The organisation which administers ATNF (5)
14. Co-discoverer of radio emission from Jupiter (5)
16. 17th letter of the Greek alphabet (3)
17. Kimono belt sash (and MP 6669) (3)
18. Desire, or the currency required for 17 across (3)
19. OverWhelmingly Large telescope acronym (3)
20. Another early Australian radio astronomer (5)
21. Australian amateur supernova discoverer (5)

**DOWN**

1. ATNF's type of astronomy (5)
2. Amounts of change (5)
3. ATNF site (5)
4. The "S" of the VSOP project (5)
6. The largest single radio telescope (7)
8. The kind of star that may appear to emit pulses (7)
12. The type of radio telescope built by 3 across and 20 across (5)
13. Equatorial constellation (5)
14. Current ATNF Director (5)
15. Previous ATNF Director (5)

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# Mopra induction weekend

Winter in the Warrumbungles holds a special interest for astronomers, the cold, dry atmosphere and the relatively high elevation provides some of the best seeing conditions in Australia. Our radio telescope in the Warrumbungles is almost two hours from its logistical support at Narrabri. This separation from the support mechanisms means that an observing run at Mopra requires a little more knowledge and independence than might be the case for a run at Parkes or Narrabri. So around this time each year, we hold a workshop on how to use the Mopra Observatory to kick off the millimetre-season which runs until the start of October. This year the Mopra induction weekend was a three-day workshop starting on 21 May 2004, running from Friday night to Sunday afternoon. The course was heavily attended by a total of 26 people from the ATNF, UNSW, USYD and Leeds University. Those people who have seen the size of the kitchen at Mopra might appreciate how cosy and friendly the twenty-six of us got in our improvised lecture theatre.

The workshop is essentially an opportunity for an astronomer with observing time at Mopra this season to get some hands-on experience at the observatory. This weekend was comprised of nearly a dozen lectures and several hours of practical interaction with the telescope and its control systems. The lectures, talks and practical demonstrations were given by a number of excellent speakers from the ATNF engineering-staff and distinguished lecturers from UNSW and other universities. Primarily, the weekend is aimed at new telescope-users; induction into safe practice, technical information on the observatory and introduction to the core of science done with the telescope. This does not mean that the workshop is solely for new Mopra users however. Each year a number of experienced people attend in order to refresh their skills, lecture on their specialities or simply add their experience to the whole. Invariably even these people come away with a deeper insight into some part of the telescope workings, either from the lectures or talking with the experts.

The weekend wasn't all work though. We drove down to Coonabarabran to have a good meal at the Chinese restaurant, an obligatory part of the Mopra experience. We also braved the cold of the Warrumbungles to put on a well-received barbecue at Mopra, cooked to perfection by the multi-talented correlator lecturer. And thus, a well-fed cluster of astronomers gathered around the classy 44-gallon drum campfire, arranged by a particularly resourceful member of the Narrabri staff, to chat and laugh well into the starry night.

I would again like to thank all the people who helped make this weekend one of the biggest and best induction weekends we've had. Next year promises even more variety as the planned upgrade of the millimetre-receiver and large band-pass spectrometer may attract different flavours of astronomers to the Mopra induction workshop.

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Photo: Martin Muehlegger

**Figure 1: Workshop participants with Mopra rock in the background.**

# ATNF apprentices

We believe that large organisations have a social responsibility to train people. At the ATNF, the Marsfield machine shop has six tradesmen, and employs two apprentices, each on four-year apprenticeships.

Michael Bourne is in the final year of his apprenticeship, having completed his three-year trade course well ahead of schedule. As a top student, he was nominated on two occasions by his TAFE college as “Rotary Apprentice of the Year” and was runner-up last year. He is now in the second year of a Mechanical Engineering Diploma. Michael loves his work and plans to continue in the machine shop for some time to come.

Our second apprentice, Michael Death, is also well ahead of schedule in his TAFE course and is achieving high marks. He already shows great confidence in using the workshop machinery and demonstrates excellent skills.

Under the watchful eye of apprentice mentor, Geoff Cook, they are encouraged in their efforts and helped with any problems. We are proud of our apprentices, who are both high achievers. They are a credit to themselves and to CSIRO.

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Photo: Geoff Cook

**Figure 1: ATNF apprentice Michael Bourne.**

Photo: Geoff Cook

**Figure 2: ATNF apprentice Michael Death.**

# Distinguished visitor program

The ATNF had the pleasure of the company of Steve Rawlings (University of Oxford) who visited for four weeks in April, ending with a thought-provoking colloquium on radio galaxies and cosmology.

We look forward to visits from the following distinguished visitors during the remainder of 2004:

- Joel Weisberg (Carleton College) who will visit from July 2004 to June 2005.
- Renee Kraan-Korteweg (University of Guanajuato, Mexico) who will visit from July to December.
- Yi-nan Chin (Tamkang University, Taiwan) who will visit in July.
- Francois Viallefond (Observatoire de Paris) who will visit in July/August.
- Phil Edwards (ISAS, Japan) who will visit in July/August.
- Trish Henning (UNM, New Mexico) who will visit in July/August.
- Tim Cornwell (NRAO) who will visit in September.
- Eric Wilcots (University of Wisconsin-Madison) who will visit from September 2004 to January 2005.
- Christian Henkel (MPIfR) who will visit from October to November.

Prospective visitors should get in touch with the Director, a staff collaborator or myself.

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# New postdoctoral fellows

### Kate Brooks – Bolton postdoctoral fellow

We look forward to the arrival, later this year, of Kate Brooks. Kate has had a long association with the ATNF having first joined as a summer vacation student in December 1993. In September 2000 she completed her PhD at the University of New South Wales and moved to Chile to take up a three-year fellowship with the European Southern Observatory (ESO). Her main role there was supporting two state-of-the-art infrared instruments at the La Silla Observatory. For the third year of her fellowship Kate held a postdoctoral research position at the University of Chile to work in the field of massive star-formation. With her Bolton Fellowship she looks forward to using the new 3-mm facilities of the Compact Array to continue her research. Kate is currently taking a maternity break after the birth of her son. She will return to Australia with her family to begin her Bolton postdoctoral appointment in December 2004. She will be based at Marsfield.

### Russell Edwards – Pulsar postdoctoral fellow

Russell Edwards completed a BSc degree in Computer Science at Monash University. In 1996/97 he was a summer student at ATNF under Dick Manchester's supervision, working on a system to record pulsar-timing data at Tidbinbilla. Following completion of his degree he commenced a PhD at Swinburne University of Technology with Prof Matthew Bailes as supervisor. Russell's thesis project was a high-latitude pulsar survey using the 20-cm multibeam receiver at Parkes, specifically optimised for the discovery of millisecond pulsars. This was very successful, discovering 69 pulsars including eight millisecond pulsars. Russell completed his PhD in 2001 and took up a post-doctoral position at the "Anton Pannekoek" Institute at the University of Amsterdam. While there he has made use of the facilities at Westerbork, mainly studying the individual-pulse properties of pulsars. With his wife and young daughter, Russell is returning to Australia in early August to take a post-doctoral appointment with Dick Manchester's Federation Fellowship team. He will mainly be working on precision pulsar timing at Parkes, establishing a "pulsar-timing array" with the ultimate goal of directly detecting gravity waves.

### Enno Middelberg – CSIRO/Bolton postdoctoral fellow

Enno Middelberg arrived at the ATNF on 31 May as a new CSIRO/Bolton postdoctoral fellow. Enno grew up in Haren, Lower Saxony, did his undergraduate degree in physics in Bonn at the Max Planck Institute for Radio Astronomy, working on EVN and MERLIN observations of Seyfert galaxies. His PhD at the MPIfR was done under the supervision of Alan Roy, who will be well known to many at the ATNF.


During his PhD, Enno spent most of his time observing nearby AGN with the VLBA. In a project to measure magnetic fields through Faraday rotation in the vicinity of nearby AGN cores, he detected a depolarising screen in front of the pc-scale radio jets in five objects. His work on Seyfert galaxies was continued with VLBI monitoring of NGC 3079 and a single-dish monitoring of a sample of Seyferts with the Effelsberg telescope.

Enno developed a phase-referencing technique for the VLBA that uses low-frequency visibility phases to calibrate high-frequency data. The technique allows observations of weak sources at higher frequencies and the measurement of positions at the two frequencies relative to each other. This is particularly interesting because a position shift with frequencies is a measure of various physical properties in the jets. Enno will be based at Marsfield and hopes to be able to participate in LBA studies of Seyfert galaxies and further improve phase-referencing techniques.

### Naomi McClure-Griffiths – CSIRO postdoctoral fellow

Naomi McClure-Griffiths will remain at the ATNF on a three-year CSIRO postdoctoral position from the end of her Bolton fellowship in September 2004. Naomi's research will continue to focus on neutral hydrogen (HI) in the Milky Way.

She expects her work over the next year or so will be dominated by the Southern Galactic Plane Survey (SGPS) Galactic Centre survey, which will be completed this year. With these data she will begin a large project studying the structure and dynamics of neutral hydrogen (HI) in the central five kiloparsecs of the Milky Way. This project will focus on understanding the relationship between the molecular ring, the bar, the three-kpc arm and inner spiral structure. Because she (as she puts it) "can never stop surveying", she has recently proposed a new HI Galactic All-Sky Survey (GASS) with Parkes to study the distribution of HI in the halo and the Milky Way environment. She hopes GASS will expand her research away from the Galactic plane at least to the halo and maybe a bit further.

### Roberto Ricci – postdoctoral fellow

Roberto Ricci graduated in Astronomy at the University of Bologna in March 2000. His degree project title was: "Polarisation properties of two Compact Steep Spectrum radio sources" and he worked at the Institute of Radioastronomy (IRA) of Bologna under the supervision of Prof Roberto Fanti and Dr Franco Mantovani. In November 2000, he started his PhD in Astrophysics at the International School for Advanced Studies (SISSA/ISAS) in Trieste. His PhD project was the study of high-frequency properties of extragalactic radio sources and their contribution to CMB anisotropy contamination. His advisors were Prof Luigi Danese (SISSA and Padua Astronomical Observatory) and Prof Gianfranco De Zotti (PdAO/SISSA). Roberto has also been an ATNF co-supervised student under the co-supervision of Prof Ron Ekers and has been working on the pilot study and the first run of the Compact Array 20-GHz southern sky survey (AT20G). Roberto will arrive in November to continue his work on this survey, partly funded by SISSA and Ron Ekers' Federation Fellowship.

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# ATNF graduate student program

We welcome Steven Longmore (UNSW) who has entered the ATNF co-supervision program with a PhD project entitled "Uncovering the Top-End of the Initial Mass Function". His supervisors are A/Prof Michael Burton (UNSW) and Dr Tony Wong (ATNF/UNSW).

It's also a pleasure to congratulate Emma Ryan-Weber on the successful submission of her University of Melbourne PhD thesis: "Neutral Hydrogen in Galaxies and the Intergalactic Medium". After finishing a short appointment at the University of Melbourne, Emma will take up a postdoctoral position at the University of Cambridge.

Finally, many congratulations to Vince McIntyre, Astronomical Applications Specialist at Marsfield, who successfully submitted his University of Wollongong PhD thesis "Star Formation and Internal Kinematics of Irregular Galaxies".

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# Articles

## A search for OH megamasers in ultra-luminous infrared galaxies

OH megamasers (OHMs) are sources of exceedingly powerful OH 1665 and 1667-MHz emission, whose line luminosity exceeds that seen in the "standard" Galactic-OH source, W3(OH) by at least six orders-of-magnitude (i.e. $L_{OH} > 10$; e.g. Elitzur 1992)[1]. Such spectacular sources are found in systems with extremely high infrared luminosity – sources that have been found to be well-correlated with galaxy mergers and strong star-formation (Clements et al. 1996). OHMs are therefore believed to be excellent tracers of merging galaxies and star formation; their importance in this context is further increased due to the possibility that present-day radio telescopes may be sufficiently sensitive to detect these systems out to high redshifts (e.g. Briggs 1998). OHMs could thus well serve as an important probe of the evolution of the galaxy merger rate as well as the star-formation history of the Universe.

The formation of OHMs is reasonably well explained by a model in which the maser levels are pumped by far infrared (FIR) transitions at 35 and 53 μm (e.g. Baan 1989); this is supported both by a strong correlation between the OHM-line luminosity, $L_{OH}$ and the 60-μm luminosity, $L_{60\mu m}$ as well as the fact that the probability of finding OHMs is significantly higher in galaxies with $L_{60\mu m} > 11.2$ in comparison with objects with $L_{60\mu m} \approx 9$ < (Briggs 1998). Indeed, Baan (1989) found evidence for a correlation, $L_{OH} \propto L^2_{60\mu m}$ , which can be understood if the FIR radiation causes an inversion of the OH populations and the resulting inverted population amplifies any background redshifted 18-cm radio continuum (since $L_{18cm} \propto L_{IR}$ ; e.g. Henkel and Wilson 1990). Of course, not all OHMs show the above background radio continuum. Kandalian (1996) later showed that the above quadratic correlation was affected by Malmquist bias; the removal of this bias resulted in the correlation $L_{OH} = (1.38 \pm 0.14) \times L_{FIR} - (14.02 \pm 1.66)$. This was further revised by Darling and Giovanelli (2002) to $L_{OH} = (1.2 \pm 0.1) \times L_{FIR} - (11.7 \pm 1.2)$, based on an Arecibo survey toward sources selected on the basis of their IRAS 60-μm flux. Note that the latter is the first large, relatively uniform OHM-survey, based on a flux-limited sample. In essence, however, the general conclusion of the above results is that it appears possible to predict the OH-line luminosity on the basis of the FIR luminosity; further, the correlation with FIR flux implies that the brightest ultra-luminous infrared galaxies are the best candidates for searches for OHM activity.

Interestingly enough, despite the above, the high FIR-luminosity end of the distribution appears to be quite poorly sampled. Only two confirmed OHMs have so far been identified with $L_{FIR} \geq 12.5$. One further system, 16300+1558, was tentatively detected by Darling and Giovanelli (2000) but their Arecibo spectrum was badly affected by RFI. It should, in fact, be emphasised that only four masers of the complete sample (see Figure 3 of Darling and Giovanelli (2002)) have *predicted* OHM luminosity $L_{OH} \geq 3$ ($L_{FIR} = 12.5$ corresponds to (predicted)$L_{OH} = 3.3$). This is unfortunate as it is precisely the high-luminosity systems that would be the easiest to detect at high redshift and hence, the systems that one would like to characterise well at low redshifts. Besides this, Darling and Giovanelli (2002) also found that the probability of finding an OHM increased from 1 in 5.5 systems for their complete sample ($L_{FIR} \geq 11$) to 1 in 3 systems for ultra-luminous infrared galaxies (ULIRGS), with $L_{FIR} > 12$; it would be very interesting to ascertain whether the probability further increases with increasing FIR flux. Finally, the only two known gigamasers, 14070+0525 (Baan et al. 1992) and 20100-4156 (Staveley-Smith et al. 1989), arise in systems with $L_{FIR} \geq 12.35$. Baan et al. (1992) suggest that the relation between $L_{OH}$ and $L_{FIR}$ becomes non-linear at the high luminosity end, implying that OH gigamasers are likely to be found in systems with the highest FIR luminosity; again, it is important to test this in a systematic manner, as it has strong implications for searches for OHMs at high redshift.

[1] *All luminosities are in logarithmic units, relative to $L_{sun}$; we use a flat $\Lambda = 0$ FRW cosmology, with $H_0 = 70$ km s$^{-1}$ Mpc$^{-1}$.*

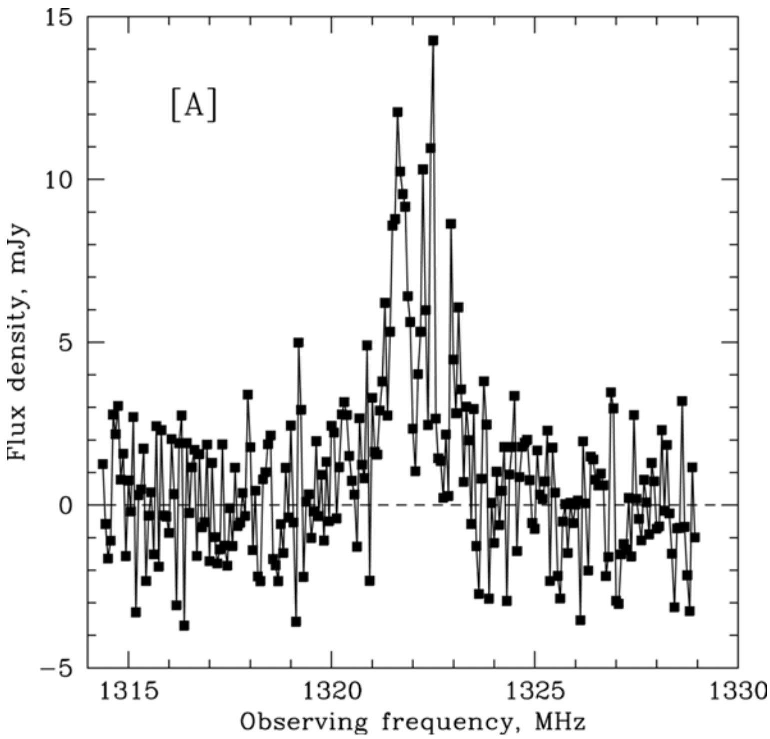


**Figure 1: 1667-MHz OH-megamaser emission from 00397-1312 (z ~ 0.262).**

## A new OHM survey

Present OHM catalogues are restricted to systems with $z \leq 0.27$; for example, the Arecibo survey of Darling and Giovanelli (2002) was effectively restricted by the RFI environment to $z < 0.23$. A far wider range of OH redshifts can now be probed by existing radio interferometers such as the Compact Array, the WSRT and the GMRT. Interferometric observations are also much less susceptible to RFI than single-dish studies, a crucial issue at the unprotected frequencies of the redshifted OH lines. It thus appears an excellent time to carry out an interferometric search for high-luminosity OHMs, in a higher redshift range than presently covered.

For this purpose, we have used the IRAS PSCz catalogue (Saunders et al. 2000) and the NASA/IPAC Extra-galactic Database to compile a list of all IRAS sources with $F_{60\mu m} > 0.8$ Jy; this has resulted in a sample of 32 systems in the redshift range $0.23 < z < 0.45$. All sources of the sample are ULIRGs, with $L_{FIR} \geq 12.2$, i.e. a predicted OHM luminosity, $L_{OH} \geq 3$; note that the FIR luminosities and predicted OH luminosities have been computed, for consistency, according to the equations of Darling and Giovanelli (2002). Twelve sources of the sample have $L_{FIR} \geq 12.5$, of which one (14070+0525) is a confirmed OHM.

We plan to carry out a systematic search for OHM emission in the remaining 31 objects of the sample, to (1) directly test whether the probability of OHM emission increases with FIR flux at the highest FIR-luminosities, (2) extend current OHM samples to higher redshifts and (3) search for systems with OH satellite-line megamasers, that might be used to measure changes in fundamental constants (Chengalur and Kanekar 2003; Kanekar et al. 2004). The Compact Array and the WSRT are perhaps the best interferometers for this purpose as they provide an excellent combination of frequency coverage, large observing bandwidths, high spectral-resolution and excellent bandpass stability. Ten sources of the sample are in the southern sky, with their redshifted-OH main line frequencies lying within the Compact Array 20-cm band; we plan to observe these with the Compact Array, and the remaining 21 systems with the WSRT, whose cooled L-band receivers can be used out to a redshift of ~ 0.45. 156 hours of Compact Array and WSRT time were allocated to the project for pilot observations in the previous cycle; the initial Compact Array results are discussed below.

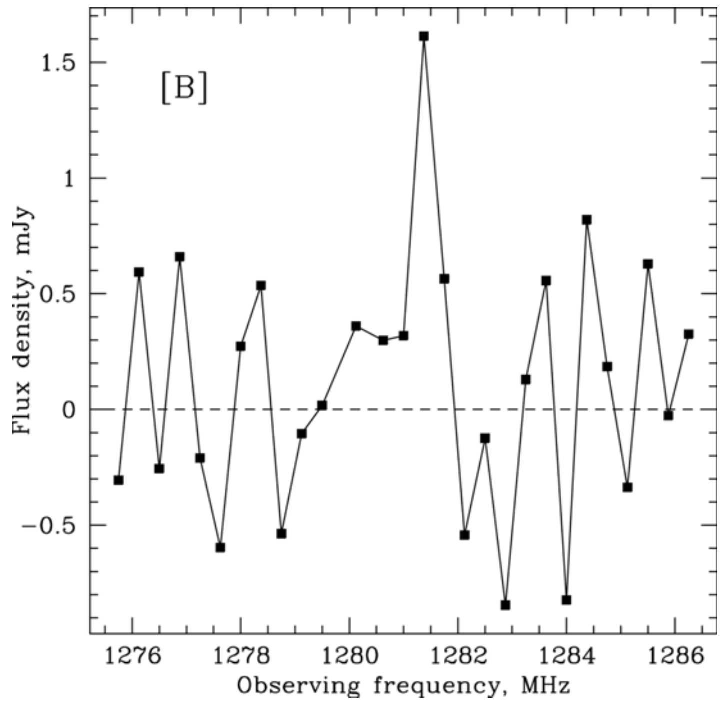


**Figure 2: Tentative detection of 1667-MHz OH-megamaser emission from 03538-6432 (z ~ 0.301).**

## First results from Compact Array observations

Nine sources of the complete OHM sample were observed with the Compact Array and the WSRT in the last cycle, in pilot observations to test the RFI environment (Kanekar 2004; in preparation). Only one of the four Compact Array sources, 00182-7112, was badly affected by RFI (at ~1256 MHz), while data on the remaining three were very clean. These observations resulted in the clear detection of a z ~ 0.26 OHM, 00397-1312, and the tentative detection of the highest redshift OHM, 03538-6432. Similarly, while two of the WSRT targets were affected by RFI, it was possible to salvage reasonable fractions of the data in all cases. The WSRT observations confirmed the z ~ 0.242 OHM in 16300+1558.

The Compact Array spectra towards 00397-1312 and 03538-6432 are shown in Figure 1 and Figure 2 respectively; here, flux density, in mJy, is plotted against observing frequency, in MHz. 00397-1312 is one of the most powerful OHMs known, with an isotropic line-luminosity $L_{OH}$ = 3.84, just below the gigamaser level. It also has the second highest redshift of any known OHM, z = 0.2617, just below that of 14070+0525 (z = 0.2644). This source is also very interesting as it shows multiple spectral components, suggestive of multiple masing sites. Some of these components are unresolved by the present observations; it is thus quite likely that this source too lies in the gigamaser category. We plan to re-observe this source with higher spectral resolution to attempt to resolve out these components. It would also be interesting to attempt to map the emission, using VLBI observations. We note that near-IR images of this source (Rigopoulou et al. 1999) show distorted outer isophotes around a single central nucleus, suggestive of merger activity (Rigopoulou et al. 1999; Veilleux et al. 2002); the source is classified as a “completed merger”.

Next, while the detection of emission towards 03538-6432 is presently quite tentative (a ~ 3.4$\sigma$ result), the data showed no evidence for RFI and the redshift is in agreement with that of optical lines. Although the OHM luminosity is not exceptional ($L_{OH}$ ~ 3, lower than predicted), it would, if confirmed, be the highest redshift megamaser known (z ~ 0.301). We plan to re-observe this system with the Compact Array to confirm the detection. This system too appears to arise in a fairly advanced merger; the WFPC2 I-band image (Bushouse et al. 2002) shows a main central source containing multiple nuclei, a clear tidal tail and other smaller tails.

Besides the above detections in 00397-1312, 03538-6432 and 16300+1558, the WSRT and Compact Array observations placed strong limits on the OH luminosities of five objects of the sample. At present, including 14070+0525, ten sources of the complete sample have been searched for OHM emission (including 00182-7112, whose data were affected by RFI) and only four detected. All of the non-detections have very high FIR-luminosities ($L_{FIR} \geq 12.5$); the upper limits on $L_{OH}$ are significantly lower in these objects than the values predicted by the FIR-OH correlation. Even amongst the detections, two of the systems, 16300+1558 and 03538-6432, have lower OHM luminosities than predicted by the correlation, suggesting that the correlation may turn over at the highest luminosities. We note that, while all four OHM detections have warm IRAS colours (with $F_{60\mu}$ / $F_{100\mu}$ ~ 0.8 – 1), no obvious trend separates these sources from the non-detections. Of course, the small number of currently observed sources makes it difficult to draw strong conclusions regarding the high-luminosity end of the OHM luminosity-function. These await the completion of observations of the entire sample.

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# A “new” spiral arm for the Milky Way?

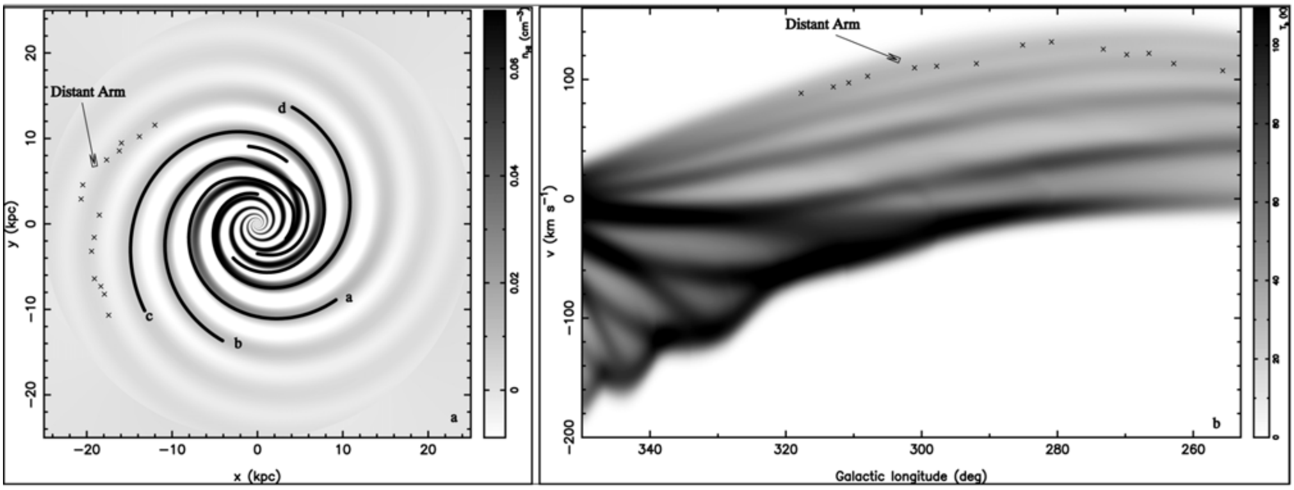


**Figure 2: *Left.* Differential HI density (spiral perturbation minus the underlying Toomre disk) for a simple four-arm Milky Way spiral model. The Sun is at (x,y) = (0 kpc, 8.5 kpc). Overlaid in solid lines is the spiral model of Cordes & Lazio (2002). *Right*. Synthetic *l-v* diagram created from the spiral pattern in the left panel. The proposed distant arm in the right panel maps to a ridge of emission at far positive velocities, as marked. (From McClure-Griffiths et al. 2004)**

constant Galactocentric radius at 16 and 24 kpc, which show that the feature extends from a radius of $R_g$ ~ 17 kpc at the low-longitude end to $R_g$ ~ 25 kpc at the high-longitude end, with an estimated radial width of ~ 2 kpc. The scale height of this feature is relatively constant along its entire length, varying between extremes of 1.2 and 1.7 kpc. We estimate the HI number-density along the mid-plane is $4 \times 10^{-2}$ $cm^{-3}$, and by integrating over the *z*-height we find that the average surface-density is $3 \times 10^{-3}$ $M_{sun}$ $pc^{-2}$. Based on the *z*-height and velocity width of the feature we estimate that a disk density of $6 \times 10^{-3}$ $M_{sun}$ $pc^{-3}$ would be required to confine the scale-height of the feature, though there is no evidence that the stellar disk extends to such large Galactocentric radii.

A ridge in the longitude-velocity diagram can be caused by two main physical effects: a gas density enhancement or a significant velocity perturbation that causes gas at different distances to appear at the same velocity. A spiral arm produces a combination of these effects. Spiral arms typically produce only small (nominally a factor of two) HI-density enhancements in the HI disk, but they also induce strong (~10 km $s^{-1}$) non-circular velocities, or streaming motions, where gas interior to an arm is pulled radially by the arm’s gravity. Because the observed feature is not at a constant Galactocentric radius and appears to be radially confined, we hypothesised that it might be a very distant spiral arm. To test this theory we first needed to understand the shape of a spiral arm in *l*-*v* space. We created a simple four-arm spiral model for the Milky Way with a pitch angle, *i*, that varies linearly from 16° at $R_g$ = 4.25 kpc to 10° at $R_g$ = 18 kpc. Using the spiral model and accounting for streaming motions around the spiral arms, we created synthetic HI spectra and constructed a synthetic *l*-*v* diagram. The face-on spiral model and synthetic *l*-*v* diagram are shown in Figure 2. The model is by no means definitive, but it does recreate many of the dominant features of the observed *l*-*v* diagram. In particular, the synthetic *l*-*v* diagram also shows a narrow ridge of emission at the most positive velocities. From our model we can show that this ridge maps to the spiral arm in the face-on diagram that passes through (*x*, *y*) = (-18 kpc, 6 kpc).

Though the observed feature can be easily explained by a spiral arm, we also considered a number of other explanations. In particular, we considered whether it might be the result of a pile-up in velocity space at the projection of the Local Standard of Rest onto the line-of-sight from a very extended, smooth HI disk or the signature of elliptical gas-orbits in the outer Galaxy. However, none of these explanations fit the data and we therefore concluded on the basis of agreement with the spiral model that the feature is best described as a spiral arm with a pitch angle of $i \sim 9°$.

Another notable characteristic of this feature is that it shifts in velocity by about 10 km $s^{-1}$ between longitudes $l$ = 275° and 295°, as seen in Figure 1. It is interesting that these longitudes agree well with the Galactic longitudes of the Large and Small Magellanic Clouds and the Leading Arm of the Magellanic Stream. In models of the orbits of the Magellanic Clouds, the Clouds should cross the Galactic plane around $l$ = 280°. We might expect that the relative proximity of the Clouds would produce a significant dynamical effect on the outer Milky Way disk. Some models, such as Weinberg (1995), even estimate that the orbit of the LMC should produce a radial shift in the HI at 18 kpc of about 10 km $s^{-1}$. The observed shift in the outer arm may be that effect.

There is still a great deal to understand about this most distant spiral arm in the Milky Way. For example, it remains to be seen whether there are any stars associated with the arm. In the future we also hope to search for evidence of star formation in the arm. Recent results from the NANTEN telescope in Chile have revealed some $^{12}CO$ emission at coincident positions in the low-longitude end of the arm (Nakagawa et al., 2004). It is too early to say whether this gas might have formed stars. We also hope that future work will be able to determine whether this feature connects with any other previously known spiral features, as it appears to in our simple model.

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# Regular items

## SKA program report

As mentioned in the February ATNF newsletter, Australia withdrew from the LOFAR project, having given it our best shot. However, our unsuccessful bid for LOFAR has resulted in several positive outcomes, including a greater international prominence of rural Australia as a potential SKA site, and a vigorous continuing collaboration with MIT.

Following LOFAR, a discussion took place of how best to refocus the ATNF SKA research projects. This resulted in a "Vision Statement", endorsed both by the Australian SKA consortium and by the ATNF Steering Committee, in which we proposed to construct an SKA Technology Demonstrator at the remote candidate SKA site at Mileura in Western Australia. We are now turning this Vision Statement into a detailed plan for the New Technology Demonstrator project. We expect funding for this project to be largely from the Australian Astronomy Major National Research Facility (MNRF), together with contributions from CSIRO and from our collaborators, including MIT and the Western Australian State Government.

The project plan is to develop a low-frequency array at Mileura capable of demonstrating the advantages and feasibility of operating a radio telescope in an extremely radio-quiet site. It will also demonstrate innovative technology for the SKA, and will achieve some significant science goals. The plan proposes that detailed design and feasibility studies will take place over the next nine months, leading up to a Preliminary Design Review (PDR) in May 2005. Completion of the Demonstrator is planned for June 2007. While the detailed configuration will not be determined until the PDR, it is likely to include Aperture Array tiles at low frequency, and a reflecting concentrator and focal-plane array feed, with beamformer, filterbank, and correlator back-ends. Other significant components of the project include integrated receivers, software, signal transport, and energy supply.

In addition, a long term radio-frequency monitoring program will be implemented towards the end of 2004, to obtain data on background levels of radio-frequency interference at Australian candidate sites. Ron Beresford has designed a suite of equipment to enable low levels of interference to be measured at several Australian sites, and will soon be putting the equipment together prior to installing it in the Australian bush.

In the last few months, the Luneburg-lens development program has moved forward to testing a prototype lens, constructed using an innovative artificial dielectric developed by CSIRO scientists. The tests confirm the earlier cavity-based measurements of very low loss of the dielectric material. However, the overall performance of the lens is limited by available manufacturing techniques. The Luneburg-lens program has been very successful in its development of innovative materials and manufacturing technology, and it has now reached the major review milestone identified in the original project plan. An external review, by a sub-committee of the Australian SKA Consortium, has recommended that this project is unlikely to produce a technology suitable for the SKA. The Luneburg-lens project is therefore now being wound down, although we will ensure that the results of the research are properly documented and patented, and that possible commercial applications for this technology will be explored.

Another area of active ATNF research funded by the MNRF is the construction of a broadband backend for the Compact Array. A major recent achievement towards this goal has been the installation of the proof-of-concept digital filter bank at the Mopra radio telescope. Current best performance of this system is 256-MHz bandwidth with 1024 frequency-channels, with a planned increase to 600 MHz by July 2004. Work is already well underway on the design of a prototype 2-GHz filter bank.

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# ATNF outreach

## *Astronomy from the ground up!*

Eighteen teachers from NSW, Victoria, the ACT and Queensland participated in a three-day astronomy workshop, *Astronomy from the ground up!*, held at the Parkes Observatory from 12 – 14 May 2004. They ranged in experience from those new to teaching to others with more than 30-years experience.

The workshop took place primarily in the 3D theatre at the Visitors Centre and the conference room at quarters, with other activities taking place on the lawn in front of the quarters and along the Avenue. It concluded with a tour of the site and a hayride on the dish.

Workshop sessions included talks on a range of subjects, practical activities, night-time viewing through optical telescopes and time for general discussion and inspection of resources. On the Thursday night a live-link to the Charles Sturt University (CSU) remote optical telescope at Bathurst allowed participants to control the telescope and take and download CCD images in real time over the Internet. Speakers were primarily ATNF staff; Jessica Chapman gave two sessions, one on the Milky Way and galaxies, the other on the life and death of stars, George Hobbs engaged the teachers with a talk on pulsars and gravity, John Sarkissian discussed how spacecraft have helped us explore the Solar System whilst Roopesh Ojha talked about "Astronomy on Ice", interweaving his year at the South pole with a talk on multi-wavelength astronomy. David McKinnon, Professor of Online Teaching and Learning from CSU talked about the remote telescope. He also ran some practical activities and helped with the night-time viewing sessions. Robert Hollow organised the workshop and presented sessions on Australian Astronomy and Cosmology. Rob also arranged activities and demonstrated a set of teacher resources, compiled on CDs, that were developed for the workshop. Food and catering was provided by both the Dish Café and observatory staff and was both plentiful and tasty. Parkes staff cooked a barbecue on the Thursday night to coincide with the viewing session under wonderfully dark skies. The Parkes Observatory worked very well as a venue and we thank the observatory staff for their help in ensuring that the workshop ran smoothly.

Overall, judging by the comments on the evaluation forms, the workshop was very successful. The teachers went away stimulated, challenged, well fed and well resourced. Common responses in their

**Figure 1: The astronomy workshop participants.**

**Figure 2: The workshop participants on the Dish.**

feedback was firstly the great value in being able to meet, talk to and socialise with the astronomers and other staff who all gave freely of their time and secondly, the obvious passion and enthusiasm everyone had for their work and research. Two comments may best sum up the teachers' feelings: "Excellent – it would rate 11 on a scale of 1 to 10" and "The best I've been to in 30-years of teaching".

The opportunity for teachers to spend a few days away from a school environment networking with peers and meeting professional scientists and engineers is one that is worth continuing in future years.

*Rob Hollow*
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## Outreach and education website

In mid-May the ATNF released a new website for outreach and education. This can be seen on the web at *http://outreach.atnf.csiro.au.*

One of the major aims of this website is to provide educational resources in astronomy, for students and teachers. At present we are developing the web content to support the astrophysics syllabus for senior high-school students in Victoria and New South Wales. We also plan to provide astronomy resources for other states in Australia, and for school students of all ages. The site also provides information about the ATNF and its history, special feature articles, visitors' information and links to public astronomical facilities in Australia.

Over the next few months we will be continuing to develop new content and facilities for this site. We welcome any suggestions and feedback on this outreach resource.

*Jessica Chapman, on behalf of the website development team*
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# Compact Array and Mopra report

## Operations

We had a good January term, with 88.2% of total time devoted to astronomy, and only 1.5% of downtime during scheduled observations. Millimetre observing had a long holiday over the Christmas. 12-mm observing began again on 16 February. This proved to be too early in the year – the observation was effectively lost to poor weather. Significant scheduling of 12-mm observations started at the end of March. Additionally a pair of 3-mm projects, that made good use of the pre-upgrade 3-mm system, were scheduled at the end of April.

With the May term being a five-month one and the first term where the full 3-mm system was being offered, the requests for time on the Compact Array was very high with an over-subscription factor of three (see the time assignment report on page 29).

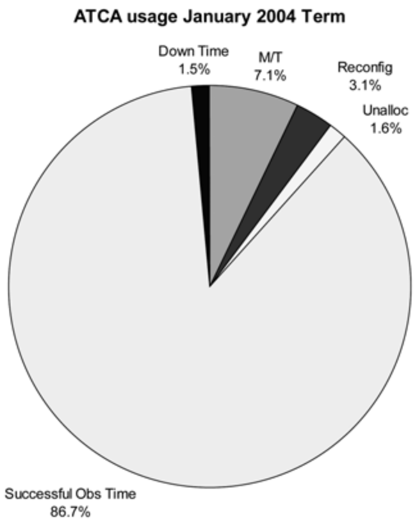


**Figure 1: Compact Array usage for January – April 2004.**

## Staff

For the first time in about half-a-year, the Observatory is now fully staffed. We welcome back Kylee Forbes, who has been on maternity leave for the last year. We also welcome new engineers Tim Wilson, Peter Mirtschin and Michael Laxen. Tim is a mechanical engineer whose role will take in all three ATNF observatories. Peter joins us as the leader of the Narrabri electronics group. His arrival will allow Brett Hiscock to concentrate more on his new role as deputy-Officer-in-Charge. Michael Laxen, an electronics engineer, adds further depth in our Electronics Group.

Crystal Gay, who had been our administrative assistant for the last two years, has moved to Dubbo for a variety of personal reasons. We thank her for her lively contribution to the observatory, and wish her the best in her future. In her place, we welcome Allison Fairfull.

## Developments

The atmospheric seeing monitor is now largely complete. This will provide a dispassionate method of assessing atmospheric stability and in determining whether conditions are suitable for 3-mm observations. See the separate article (page 8).

Plots of the atmospheric seeing monitor output are now available through an early version of the new monitor-point display system. This new system gives greatly improved flexibility in analysing a range of Compact Array monitor data – give us your feedback on this next time you are at the Observatory!

Regular visitors to the Observatory will notice a few changes: we have recently had work done on the site roads, particularly the entry road. The work, in part, stabilises the entry road, which had started to degrade rapidly in the last six months. This stabilisation work is a band-aid while we seek funding for a more extensive maintenance program. Users of the Lodge will notice the appearance of phone/internet connections in each room. This is part of a site re-cable program, which is upgrading internet/phone connections within and between a number of buildings.

A less conspicuous addition to the Observatory is a rack containing a cluster of PCs. Located in the screened room, this cluster is owned by Swinburne University. The cluster will be used for baseband recording, ultra-high resolution spectroscopy, near-real time VLBI demonstrations, RFI analysis and pulsar timing.

The observatory's online calibrator database is constantly being added to, with better flux and ancillary information, and occasionally with new calibrators. The most noticeable recent addition is the improved characterisation (flux density and visibility-function measurements) of 12-mm calibrators. In addition, flux measurements have been made on about 120 bright 3-mm calibrators. This winter, Mars and Uranus are roughly 12 hours apart on the sky, and so will make flux calibration at 3-mm wavelengths somewhat simpler.

A new version of the Compact Array Users Guide is now available on the web and as hard copies.

The Narrabri Visitors Centre is just starting a significant change in direction. The focus of the Centre is going to shift from the inside of the building to displays in the landscaped area surrounding it. The inside of the Visitors Centre building will be largely used for group visits.

### Winter-2004 observing plans

The next stage in the MNRF millimetre upgrade, with the outfitting of five Compact Array antennas with 3-mm systems has started. The millimetre-systems on antennas 3 and 4 were switched off, warmed and shipped down to Marsfield on 15 May. They will return to Narrabri, along with a new millimetre-receiver package for antenna 2 on 15 June. The Compact Array will shut down during the second-half of June to allow for the installation of these new systems as well as the rebuilding of the systems in antennas 1 and 5.

Soon after the end of the shutdown, the new systems will be operational from 85 to 105 GHz. Initially, paddle calibration only (no noise diode) will be available on all antennas.

At the time of writing, it is believed that the 3-mm systems will be ready for oberving when the bulk of the millimetre observing starts on 23 July. Some delays in the development of the new systems mean that three 3-mm observations in early July are not likely to be able to go ahead.

In addition to the millimetre-receiver work, the shut-down period is an opportunity to perform many other sizeable parcels of work that are not normally possible. This includes some cryogenic work, generator servicing, turret junction-box replacement, local-oscillator work and monitor hardware changes.

### Flexible scheduling of 3-mm observations

As in previous winters, we had planned to use “swap scheduling” to achieve some robustness to poor weather during scheduled 3-mm observations. The swap-scheduling system relies on the use of “centimetre partner proposals” for swapping in poor weather. Unfortunately this scheduling approach has not worked this winter as there was an inadequate pool of centimetre proposals that were suitable for swapping. For this winter, some flexibility has been maintained by the appropriate scheduling of some Director’s Time. We are now starting the process of consulting the user community to determine the method of achieving flexible scheduling in winter 2005.

### Mopra

Mopra has generated quite a few low-points and high-points in the lead-up to the start of its winter season.

The achievements at Mopra include the integration of the new antenna-control system (which has greatly reduced some latencies in the system); the implementation of on-the-fly mapping and the adaptation of Parkes multibeam software (by Mark Calabretta) to generate images from these data; internet renumbering; subreflector adjustment (resulting in improved efficiency and beam-shape), and the installation of an interim version of the Mopra wideband-filterbank. The interim filterbank will be a 600-MHz wide, 1024-channel system. The final filterbank, which will be installed after the end of the Mopra winter season, will have 8-GHz bandwidth and about 8000 channels per polarisation. This, together with the installation of a Compact Array-style receiver package, will greatly simplify Mopra maintenance and tuning, as well as substantially increase its instantaneous productivity.

The low points of the lead-up to the season included frustrating intermittent problems with the uninterruptible power supply, the need for an emergency overhaul of the backup generator, the failure of a component in the SIS receiver and persistent croygenics problems. We believe these are largely behind us now.

The third annual Mopra Induction Workshop was held on the weekend of 22 – 23 May. See the separate article on this very successful and enjoyable workshop. The Mopra millimetre-observing season began on 23 May, immediately following this workshop, and continues through until mid-October.

Despite the effort and resources expended on Mopra over a number of years, the scientific productivity of the telescope is far lower than for the Compact Array and Parkes. This is so even after adjustment is made for its more modest operating budget. We are currently exploring with the user community ways to improve its scientific productivity.

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# Parkes Observatory report

## Visitors Centre and outreach

A Teacher Workshop with the theme of "Astronomy from the Ground Up!" was held at Parkes in early May. Organised by Rob Hollow, Education Officer, the workshop was aimed at teachers of years 7 – 10 science and was a great success (page 23). Congratulations and thanks to Rob and all the other speakers and supporting staff. Such workshops are planned to become a regular event.

The Parkes Observatory is organising an open weekend for later in the year. The most probable date is the 28 and 29 August 2004. Volunteers from other ATNF sites willing to help out with the myriad jobs that need to be done to look after the expected multitudes of visitors will be welcomed with open arms!

## Receivers

The refurbishment of the 21-cm multibeam receiver is proceeding well, and it is expected to be back in operation on the telescope in September. When the dewar was first opened we discovered a nasty surprise: indium sheet used to ensure good thermal conduction at critical joints had reacted somehow, bonding to the adjoining copper and leaving a powdery deposit. This prompted a re-design of the mounts for the low-noise amplifiers and the new mounts have now been manufactured, polished, gold plated and are being installed as this is being typed. The original plan to replace all 26 low-noise amplifiers had to be revised as a result of the additional unplanned work required, and the pressure on available staff resources associated with the 3-mm upgrade of the Compact Array. As a result ten new amplifiers will be installed in this refurbishment and 16 of the original amplifiers will be re-installed. Indium won't be used between the new mounts and the new LNAs. The remaining 16 LNAs and some further less critical work will be completed in a second refurbishment which will take place around late 2005.

The new coaxial 10/50-cm receiver installed at the end of October 2003 has become a standard workhorse for pulsar observing. A significant slope across the 10-cm bandpass has been addressed and a significant improvement has been achieved. Inter-modulation issues affecting the 50-cm bandpass have also been addressed through a change of amplifiers in the RF module but it is too early at this stage to assess the effectiveness of this change.

Initial design of a new K-band feed has been completed by Christopher Granet from the ICT Centre as the first stage of a planned upgrade aimed at taking advantage of the upgraded reflector surface. The intention is to combine the new high performance K-band LNAs developed for the Compact Array and Mopra with the upgraded 55-m diameter surface.

## Interference mitigation

The considerable interference from digital TV transmitters in the 50-cm band has received plenty of attention over recent months, and two different active RFI-mitigation techniques are showing promise. One effort has been led by Mike Kesteven and George Hobbs, the other by Frank Briggs and Brett Little. Both rely on using reference antennas which to date have been purpose-built yagis pointing at the known interference, cross-correlating the reference signal and the signal from the telescope, and subtracting the interfering signal from the astronomical signal in software. In what may be thought of as a response to the apparently paradoxical comment that "the interference can be removed effectively providing it is strong enough" has led to an effort to modify the 3.5-m dish from the de-commissioned Parkes-Tidbinbilla-microwave link for use as a reference antenna pointing at the Mt Ulandra transmitter near Cootamundra. The effect of RFI in this 50-cm band is certain to worsen with the planned switching on of a further four commercial channels from Mt Ulandra over the next year or so.

Mal Smith has established a new set of web pages where information relating to Radio Frequency Interference, particularly as it affects Parkes Observations, will be available. The current (temporary) address is *www.parkes.atnf.csiro.au/people/msmith/rfi*. Mal is the prime mover behind the characterisation of RFI at Parkes, and will be using the Interference Measurement System he has developed to characterise and monitor off-site intereferences.

New cages for on site PCs designed and built by Parkes staff have now been tested and shown to provide up to 30 dB suppression of RFI at frequencies below 2 GHz. Visitors will start to see these cages surrounding site PCs over coming weeks.

## Backends

Use of the Wide-Band Correlator is becoming increasingly routine with a wide range of receivers. Closer integration of the pulsar backends and the Telescope Control Software means that it is becoming increasingly common for two and sometimes three pulsar backends to be used simultaneously.

## Operations

Telescope operations have continued essentially trouble free, with 1.2% of time lost to equipment faults in the year to date, and 2.3% lost to weather. This loss to weather – essentially all the result of high winds – is a much better figure than the long-term average of around 3.8% and is a welcome relief after some very windy months in 2003.

In an attempt to solve a particularly elusive drive system fault – which manifested itself as a lower than expected drive-rate out of the telescope limits, making un-stowing a very slow operation – Andrew Hunt designed and built a completely new “rates generator box” which sits inside the Manual Control Panel of the telescope. The old rates-box was the only remaining part of the drive system which was both critical and completely undocumented. The new component has worked faultlessly and provides additional flexibility which we hope to take advantage of in the future. Inevitably, the fault that drove this exercise reappeared soon after the replacement was effected, clearly indicating that it didn’t originate from the rates box at all and it was then speedily identified and fixed. Further work on the drive control software has led to the identification and correction of a number of long-standing issues, the most disconcerting of which has been the mysterious “thumping” of the azimuth drives heard by many an observer in certain circumstances.

## Site changes

The revamped Library and computer workspace for visitors in the Opera House (the Admin building) is nearly completed. Renovations recently completed in the Quarters include new window-blinds and curtains, new beds, and a new laundry to match the new ladies bathroom. Work on a new kitchen and upgraded dining room should start soon, as should a million dollar upgrade of through-road from the Newell Highway to the site.

## Staff

Anne Evans has recently joined us as a member of the cleaning staff and Quarters team.

John Sarkissian has taken on a new role with Dick Manchester. John will now spend 50% of his time working with Dick Manchester and his team observing an array of millisecond pulsars in a project which aims to investigate the stability of terrestrial clocks, improve the understanding of the dynamics of our Solar System, and maybe even detect gravity waves. John will continue as an Operations Scientist 50% of his time, as part of a team supporting the many observers who come to use the telescope.

Andrew Hunt has recently clocked up 35 years of CSIRO service. Andrew is the second-longest serving ATNF/CSIRO employee, behind only Graham Moorey who has been with the organisation for a few months longer.

Dave Catlin, our receiver technician, has resigned from the ATNF and returned to Sydney for family reasons. Dave has been a great asset in the18 months or so that he has been at Parkes during which two, brand new receivers have been commissioned and one seeming fixture in the focus cabin – the 21-cm multibeam – was removed. Dave will be sorely missed and we wish him well.

Visitor Centre (VC) staff recently demonstrated their aptness to their jobs when their positions were externally advertised. Until now positions at the centre had been filled informally but to enable two part-time appointments and comply with the Enterprise Bargaining Agreement all Parkes VC positions were openly advertised. Staff approached the process of applying for their positions professionally and positively, for which they are commended. Congratulations go to Laurelle Price and Lyn Milgate who have been appointed to part time positions and to Raymond Walker, Karin Unger, Tricia Trim and Terri Wilkie appointed as casuals. Julia Hocking continues one day a week in the VC in addition to her duties as John Reynolds’ PA.

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# Time assignment information

### Time assignment statistics

The ATNF now has two six-month observing semesters per year with application deadlines on 1 June and 1 December. The first six-month semester will begin on 1 October 2004.

Statistics relating to time assignment and user satisfaction on ATNF facilities can be seen on the web at the address *www.atnf.csiro.au/observers/tacstats.* These statistics are monitored as part of the ATNF's performance evaluation.

The 2004 MAYT currently underway is a transition term of five months (May – September) before the full change to six-month semesters. For the 2004 MAYT, the ATNF received an exceptionally large number of proposals with 122 proposals for the Compact Array, 35 for Parkes, 18 for Mopra, four for VLBI and three for service observing with the Tidbinbilla 70-m antenna. The unprecedented number of proposals received for the Compact Array reflected a very strong user interest in the new 3 and 12-millimetre systems. Approximately 45% of the total time requested was for 3 and 12-mm observing.

The over-subscription rate at the Compact Array for 2004 MAY term was 3:1, approximately 50% higher than usual. As a consequence of this, some moderately-ranked proposals that would normally have been allocated time were unsuccessful this term. Of the 122 proposals, 57 were scheduled. For Parkes the over-subscription rate was close to 1.0 and 32 of the 35 submitted proposals were accepted and scheduled. For the coming 2004 OCT semester, the over-subscription rates are 1.75 for the Compact Array and 1.2 for Parkes.

Time allocation for all proposals is done on the basis of scientific merit. Of the proposals allocated time, typically 40% of scheduled time have overseas PIs while approximately 35% and 25% have PIs at the ATNF and at other Australian institutions. In 2003 the proposals included some 410 authors. Of these 45 were from the ATNF, 85 were from 14 other institutions in Australia and 280 were from 120 overseas institutions in 20 countries.

In general the feedback from observers is very positive. In 2003 the average of all measured feedback items was 89% for the Parkes Observatory, 84% for standard (cm) observing at the Compact Array, and 77% for millimetre observing with the Compact Array.

### Compact Array advice

In 2004 October semester, observing will be possible with the standard 20, 13, 6, 3-cm and 12-mm systems on all six antennas. Additionally, five antennas will be equipped with 3-mm systems. It is anticipated that no 3-mm observations will be scheduled after October, and no 12-mm observations after November. Some 12-mm observations may be scheduled in March 2005.

In both the 3-mm and 12-mm systems, when observing at two simultaneous frequencies, the frequencies cannot differ by more than about 2.5 GHz (see online documentation for exact specification). Observing in the 3-mm band preferably requires an observer present who has had previous experience with the Compact Array 3-mm systems.

The swap method of flexible scheduling will be used for 3-mm projects. Service-mode observing will be supported for centimetre projects which can be scheduled as swaps.

### Mopra advice

For 2004 October semester, proposals may be considered for Mopra radio telescope where they can demonstrate that Mopra offers a significant advantage over other facilities and/or where a substantial time is required. The standard centimetre (20, 13, 6 and 3 cm) and 12-mm systems will be available.

Please note that for observations of three days or more we require that two or more observers should be present at Mopra with access to an available car.

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*Bob.Sault@csiro.au)*

# ATNF publications list

Publication lists for papers which include ATNF data are available on the web at: *www.atnf.csiro.au/research/publications*.

Please email any corrections or additions to Christine van der Leeuw *(Christine.vanderleeuw@csiro.au)*. This list includes published refereed articles including ATNF data, compiled since the February 2004 newsletter.

Papers which include one or more ATNF staff are indicated by an asterisk.

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