ATNF News

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Discovery of pulsed OH maser emission stimulated by a pulsar

Pulsars have proved to be outstanding probes of the interstellar medium (ISM). We have recently embarked on a new type of pulsar-ISM study – binned pulsar spectrometry of the OH line. We are using techniques similar to those we developed in an earlier extensive series of HI pulsar spectrometry measurements. Using this procedure, we accumulate spectra toward pulsars separately during the pulsar pulse and in the interval between pulses. In this fashion, we can isolate the effects of the ISM on the pulsar signal alone in order to study the medium along the line of sight.

We observed eighteen low-latitude, inner Galaxy pulsars. We achieved success with PSR B1641-45. Our new observations mark only the second successful detection of interstellar OH lines in a pulsar spectrum, and the first time they have been seen in emission as well as absorption. The emission line is caused by maser processes.

Although there is extensive indirect evidence for maser activity in the ISM, stimulated emission of radiation has never been *directly* observed in astrophysical situations. In this case, the broadband pulsar spectrum exhibits excess line emission at 1720 MHz as the pulsar's photons stimulate the creation of additional photons in an intervening OH cloud. This excess emission switches on and off with the pulsar, clearly demonstrating its stimulated nature. Hence our measurement marks the first explicit detection of stimulated emission in the ISM.

Figure 1 displays the 1720-MHz spectra toward PSR B1641-45 which directly demonstrate the process of stimulated emission. The pulsar-*off* spectrum, acquired in the interval between pulses, shows both emission and absorption against other background sources lying within the Parkes beam. The pulsar-*on*

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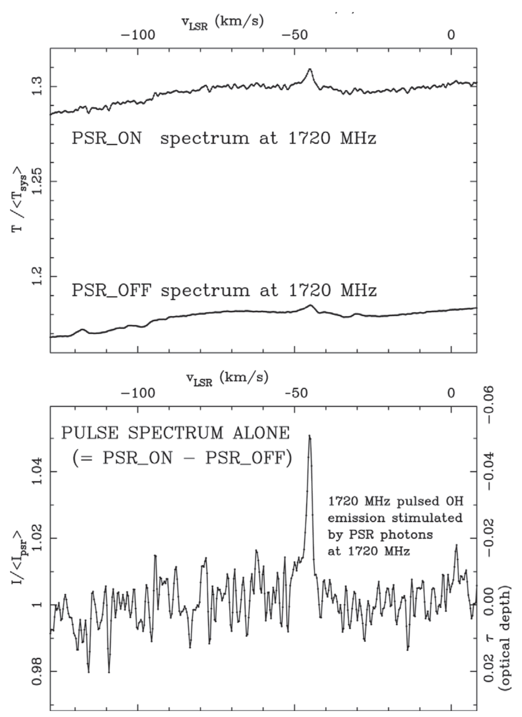

Figure 1: Discovery of pulsed interstellar OH maser emission stimulated by pulsar B1641-45. Top: The "pulsar-*on*" spectrum, acquired during the pulsar pulse, and the "pulsar-*off*" spectrum, measured in the interval between pulses. The two spectra exhibit both emission and absorption against other (non-pulsar) background source(s) lying within the Parkes beam, while the pulsar-*on* spectrum additionally contains the pulsar signal. Bottom: The pulsar spectrum, the difference of pulsar-*on* and pulsar-*off*, illustrating the pulsar signal *alone* as absorbed (or in this case, amplified) by intervening OH. The spike in this spectrum at v_{LSR} ~ –45 km/s results from excess emission in an OH cloud, stimulated by pulsar photons.

Editorial

Welcome to the February 2005 ATNF newsletter. It has been a pleasure to put together our first newsletter issue for the year; as usual we have reports covering a wide variety of subjects. Our thanks to all our contributors.

The discovery at Parkes of the first direct detection of stimulated emission in our Galaxy in the form of pulsed maser emission is reported by Joel Weisberg and forms our cover article in this issue. Read about the discovery of a hitherto unobserved phase in the life of a star in the act of forming its planetary nebula as described by Jessica Chapman on page 18. On page 10 Maxim Voronkov reports the discovery of new examples of the rare methanol maser line transitions at 104.3 GHz and 9.9 GHz.

The recent Huygens Probe tracking in which several ATNF telescopes played crucial roles provided much excitement and well deserved satisfaction at the flawless performance. We have two reports on the challenging Huygens experiments on pages 6 and 8.

On page 12, Neil Killeen provides an update on the multi-faceted work in progress for the Virtual Observatory project. Wayne Orchiston and Bruce Slee present a historical perspective with a review of the work of Alex Shain, one of the pioneers in Australian radio astronomy.

We have several other news and regular items where you will find useful information. We hope you enjoy this newsletter. We welcome your comments and suggestions. You can contact us at *newsletter@atnf.csiro.au*.

The ATNF newsletter is also available on the web at *www.atnf.csiro.au/news/newsletter.*

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From the Director

The recent decision by the CSIRO executive to support the development of a world-class demonstrator of Australian SKA technology at the proposed SKA site in Western Australian is very positive news for the Australian astronomy community. It demonstrates CSIRO's ongoing commitment to invest in radio astronomy aligned with its strategic goal of helping Australia play a leadership role in major international science facilities such as the SKA.

The continuing international impact of Australian radio astronomy plays a key role in demonstrating that Australia has the capacity to deliver world-class science outcomes from such investments. In the last few months alone, this is exemplified by the selection of the double pulsar as one of Science magazines "top 10 scientific results of 2004", the role played by the ATNF telescopes in the Huygens mission (see this newsletter) and the contribution made by the Compact Array in the observation of SGR1806-20 which has shed new light on the magnetar phenomenon.

An equally important factor in CSIRO's ongoing support for SKA development lies in the opportunity to work with other CSIRO divisions and engage with our industry partners in challenging engineering problems, addressing one of Australia's research priorities in "Frontier Technologies". In particular, the increased engagement of the CSIRO ICT Centre in these new developments capitalises on CSIRO's unique ability to contribute across a wide range of technologies (antennas, beam-forming, signal processing). This will deliver enhanced engineering outcomes not only for Australia but for the broader international SKA collaboration.

The international SKA project also continues to grow. At the beginning of March, the International SKA Program welcomed New Zealand as the 17th member of the SKA consortium. New Zealand has joined as members of the re-named Australasian SKA Consortium. The Australian/NZ collaboration in the SKA program will be pursued through the initial development of trans-Tasman VLBI as part of the eVLBI program and through the potential addition of outlying SKA stations in New Zealand as part of Australia's site bid to the International SKA Consortium.

Brian Boyle
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Letter to the Editors

Dear Editors

I read with interest Dr Brian Robinson's obituary by Helen Sim and Wayne Orchiston in the ATNF News Issue No 54, Oct 2004. There is a paragraph on page 12 that I felt reflects poorly on my long time colleague, John Murray. It refers to a blunder in which Brian and I were involved. I feel obliged to give you my version of that sad event.

It is quite true that John Murray had been checking the multi-channel filter bank when, unknowingly, Brian and I started our observations of the OH line radiation in Sgr B2. No difficulty there, John stopped work as soon as we asked. When you have as careful and meticulous an engineer as John on the job you are only too grateful for his interest in the equipment (which, incidentally, he had designed and built with the aid of a superb wiring performance by a young apprentice, Mal Sinclair!). It would have been a truly extraordinary occurrence and totally out of character had John not returned all of the units he had been checking.

The blunder was made by no one else but me – and it happened this way: The filters were followed by a corresponding set of synchronous detector units. The observation showed the very deep and widespread absorption of OH in Sgr B2. However, channel 31 (if my memory is correct on the number) remained on the zero line. That very unit had given trouble in the past and in view of that wide absorption I was idiotic enough to declare that we should ignore channel 31 and look into its trouble later, meanwhile to carry on with the observations. I state the obvious by writing that at the time we never expected to see anything but absorption. The narrow OH emission line occurred in channel 31 and was strong enough to return the level from the deep absorption back, not part of the way or beyond, but just to zero. So a combination of bad science and bad luck caused the disaster.

Yours sincerely
R X (Dick) McGee

Editors' note: We thank Dick McGee for providing us with this interesting account of the day in 1964, when the OH maser line was seen in emission at the Parkes radio telescope, but not recognised as such. This occurred a year before the famous 1965 Nature paper by Harold Weaver et al. announcing the discovery of OH maser emission.

A new proposal application system for the ATNF

We are developing a new web-based application called OPAL that will replace the current system for telescope proposal applications. The present system has been in place for almost 15 years and has become outdated and unwieldy.

OPAL will provide a set of user-friendly web-based tools for astronomers that can be used to prepare and submit telescope proposals. These tools will be available through an application that runs on the ATNF website, with a graphical user interface (GUI). This will enable astronomers to:

- create or modify proposal cover sheets;
- create or modify observations tables and source lists;
- submit, resubmit, withdraw and print proposals;
- share proposal files with co-authors; and
- access other online facilities such as sensitivity calculators and data archives.

Following a proposal submission, email acknowledgment will be automatically sent to all authors on the proposal. OPAL will provide an electronic archive of submitted proposals and astronomers will be able to access their previously submitted proposals.

It is intended that OPAL will also be useful to telescope schedulers, time assignment committee members and ATNF administrators. In addition to the proposal tools, OPAL will have a number of "backend" facilities to provide information required by these groups.

At present we are working on the requirements specification for OPAL. We plan to have a prototype version of OPAL operational by August` 2005. Please email any enquiries to Jessica Chapman or Chris Owen.

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Federation Fellowship symposium

Astronomers from near and far converged on Mt. Stromlo Observatory on 22 and 23 November to hear talks by Australian astronomy's three ARC Federation Fellows (Michael Dopita, Ron Ekers, and Dick Manchester), two of whom are affiliated with ATNF. The wide-ranging program also included 14 talks by researchers working in extragalactic astronomy, pulsar timing and gravitational waves. As the symposium was combined with the 9th annual Charlene Heisler workshop, topics related to starburst and active galaxies featured prominently in the program. Rather than try to summarise all of the talks here, or run the risk of omitting someone's favourite, this article just covers the three Federation Fellowship talks, and interested readers can view the slides from all of the talks online (*www.atnf.csiro.au/research/conferences/ffsymp2004/*).

Mike Dopita gave the first talk of the meeting, detailing recent work by his group to understand the ultraviolet-to-radio, spectral energy distribution (SED) of starburst galaxies. A principal motivation is to shed light on why various star formation tracers (such as the ultraviolet, far-infrared or radio continuum) tend to correlate with each other, and thus improve on them to better ascertain the star formation history of the universe. Modelling the SED is a difficult business, however, and requires accurate treatment of both the gas and the dust physics, as well as following the evolution of HII regions. An important result of the modelling thus far is a strong dependence of the far-infrared SED on the interstellar pressure, which results from HII regions in high-pressure zones having higher temperatures and smaller radii.

Ron Ekers focused on the mystery posed by the correlation between the radio and far-IR emissions in galaxies, both of which (as mentioned above) are believed to trace the star formation rate. The tightness of the correlation, and the fact that the radio emission is primarily non-thermal in origin, raises the question of what might couple the interstellar magnetic field and cosmic-ray density with the thermal radiation from heated dust. The rather provocative suggestion offered by Ekers was that an increased cosmic-ray flux inhibits low-mass star formation by increasing the ionisation fraction, thereby raising the far-IR luminosity as more mass goes into high-mass stars. In some cases this can lead to a runaway process which would be observed as a starburst.

Dick Manchester rounded off the Federation Fellow talks by describing how the tried and true technique of radio pulsar timing offered new opportunities to explore the frontiers of gravitational wave astronomy. One recent highlight was the discovery with Parkes in 2003 of the first double-pulsar system, known as PSR J0737-3039A/B. Not only does this system offer a fantastic laboratory for seeing relativistic effects in action, but it has also significantly increased the predicted rate of double neutron-star coalescence, an important target for gravity-wave detectors. A far more ambitious application of pulsar timing is to detect the stochastic gravity-wave background by accurately timing a network of the most "regular" pulsars across the sky. Such a program is now underway at Parkes, and has the potential to make the first direct detection of gravity waves.

The symposium ended with a panel discussion, including the three Fellows and moderator Rachel Webster, about the future of Australian astronomy, a timely subject given that the community is preparing its next 10-year plan. Among the themes that were stressed was the importance of student training, especially for developing instrumentation skills and ensuring all students have a basic grasp of research in all areas of astrophysics.

The organisers would like to thank the Stromlo staff for helping to get the Duffield Lecture Theatre ready in time for the meeting (the acoustics are great!), and Sue Little for handling all kinds of last-minute details both before and during the meeting. Support for the symposium came from the three Federation Fellows as well as their host institutions.

Tony Wong
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Pinpointing Huygens: VLBI observations of the probe's descent

On 14 January 2005 the European Space Agency (ESA) Huygens probe descended on to the surface on Saturn's moon, Titan. During the descent and for the three hours that the probe continued transmitting after it landed on the surface, the ATNF radio telescopes – Parkes, the Compact Array and Mopra, along with the University of Tasmania's telescopes in Hobart and Ceduna and other telescopes in the USA, China and Japan were used to track the trajectory of the descent using the technique of Very Long Baseline Interferometry (VLBI).

Figure 1: The twin-engine Cessna 310R chartered to bring back the Compact Array, Mopra and Parkes data to Marsfield as quickly as possible so a sample of the recorded data could be transferred immediately to JIVE to allow a "quick look" correlation of the VLBI data.

Photo credit: Chris Phillips

As the probe parachuted to the surface of Titan, the data gathered by its on-board science packages was transmitted back to the Cassini spacecraft which stored the data and then re-transmitted it back to Earth after the descent. The VLBI experiment, which was coordinated by the Joint Institute for VLBI in Europe (JIVE), directly observed the carrier signal of the transmission from Huygens to Cassini. The aim of the VLBI experiment was not to try and decode the transmitted data, as the received signal strength on earth was too weak to allow this even with the largest telescopes, but to pinpoint the exact location of the probe during its descent. Simulations by JIVE have shown that the position of the probe can be measured to an accuracy better than 1 km every minute and the velocity measured to better than 1 metre per second. Combined with measurements of the Dopper shift of the carrier signal (see the separate report on the Doppler Wind Experiment), this will allow the full three-dimensional trajectory of the descent to be re-constructed. As Titan has an appreciable atmosphere the probe's parachute was expected to be caught by these winds and the VLBI observations would allow a direct measurement of the wind speeds through a cross-section of the atmosphere. Because the signal was so weak the experiment depended crucially on having at least one large telescope in the array. At the start of the experiment this role was filled by the 100-m Green Bank Telescope (GBT) in the USA, but it could not track the probe for the entire experiment. A few minutes after Titan set at the GBT, it rose above the elevation limit at Parkes which tracked it for the rest of the experiment.

The basic observing mode used a standard phase referencing technique where the telescopes nodded between the Huygens probe and a near-by background radio galaxy. However, the specific observing set-up required significant changes and upgrades to accommodate the experiment. Because the processing of the Huygens signal will be done using a software correlator (the required spectral resolution is around 1 Hz, hundreds of time higher than is achievable by normal VLBI correlators), the recording had to be made using disk-based recorders rather than the standard tape-based S2 system. Thanks to recent work by the University of Swinburne and the University of Tasmania, all Australian VLBI antennas were already equipped with appropriate disk-based recorders. The background radio galaxy is weak but a strong detection was required to provide the desired high-precision position measurements. This was done by recording as large a bandwidth as practical, a total of 128 MHz (a data rate of 512 Mbps, enough to fill a CD every 10 seconds) which was twice that possible with pre-existing hardware. A new Data Acquisition System (DAS) had to be assembled and others moved between telescopes. A further complication was that the frequency of the carrier, 2040 MHz, is non-standard and out of range of standard receivers. Some creative engineering was needed to extend the range of the receivers to this frequency. Unfortunately, the frequency was too low for the Compact Array antennas to be modified so the Compact Array could not be used to track the probe. However, the array was included in the VLBI experiment to observe the calibrator sources which were also observed at frequencies accessible to the Compact Array.

Because of the non-standard nature of this experiment and the one-shot nature of the observation, a number of practice observations were made before the event to iron out any problems that could occur. The first test did not look good for Mopra as a hard-disk failure on the VAX one hour before the experiment meant observations there had to be cancelled. Things worked much better for the second test in November and in January we were confident everything was working well.

On the night of the experiment, the signal was first picked up by the GBT confirming that the parachute was successfully deployed and the probe was transmitting. At 11:29 AEDT, when Titan became visible at Parkes, the signal could immediately be detected. Sixteen minutes later Parkes could easily see that the probe had landed on the surface based on the characteristic of the changed Doppler shift. It was not known how long the probe would last on the surface before the batteries went flat or froze. The experiment was scheduled to last almost four hours after the landing, which was considered extremely optimistic (a few minutes to an hour was considered more likely). At 2:56 am when Titan set at Parkes the probe was still transmitting strongly. This triggered a series of frantic emails to VLBI antennas in Europe trying to arrange an ad-hoc VLBI observation with no preparation time!

Because VLBI telescopes are not connected by network links with enough bandwidth required for real-time correlation of the data, in general we cannot know until the data are shipped to the central VLBI correlator if the observations are successful. However, the team at JIVE was keen to know the success of the experiment quickly, so it was decided to get the data from the ATNF telescopes to JIVE in the Netherlands as quickly as possible. To allow this, at the end of the experiment at 3:30 am, Chris grabbed the disks from the Compact Array recorder and jumped in a taxi to Narrabri airport to board a waiting charter plane (Figure 1). This flew him back to Sydney via Coonabarabran and Parkes airports, collecting the Parkes and Mopra data en route.

Once back at ATNF headquarters in Marsfield the disks were re-loaded onto a waiting PC to be sent to JIVE. To facilitate a speedy transfer of data, nine research and education networks collaborated to give us a dedicated door-to-door gigabit connection from Marsfield to JIVE. The organisations involved included CeNTIE and AARNet within Australia, Pacific North West in the USA, CANARIE in Canada, and SURFnet in Europe. This allowed us to transmit a subset of the recorded Parkes and Mopra data for JIVE to process on their VLBI correlator. After a brief period translating the data format and copying to their local recording media, JIVE was able to confirm fringes on the calibrator sources between Parkes and Mopra.

The disks have now all been sent to JIVE and they have been busy translating the data format and doing initial correlation. So far everything looks like it has worked well. They have been able to successfully detect the probe signal in the Parkes VLBI data (Figure 2). The full 17-station correlation is expected to start soon. Then the complicated job of detection of the probe signal in the interferometry data and modeling the probe velocity will commence. As processing of this experiment is even more difficult than the observations, it will be a while before the full results are available.

The VLBI observations were originally envisaged to complement the Doppler Wind Experiment (see separate report from Parkes), which used special purpose hardware installed on Cassini as well as Parkes and the GBT. However one of the two receiving channels on Cassini was misconfigured, meaning all the Doppler measurements from Cassini were lost. While the DWE data from Parkes and GBT can replace the Cassini data, there was a 20-min gap where Titan was below the horizon at both Parkes and Greenbank. It now looks like JIVE will be able to use the VLBI data from the smaller telescopes to bridge this gap and allow Doppler measurements for the entire descent.

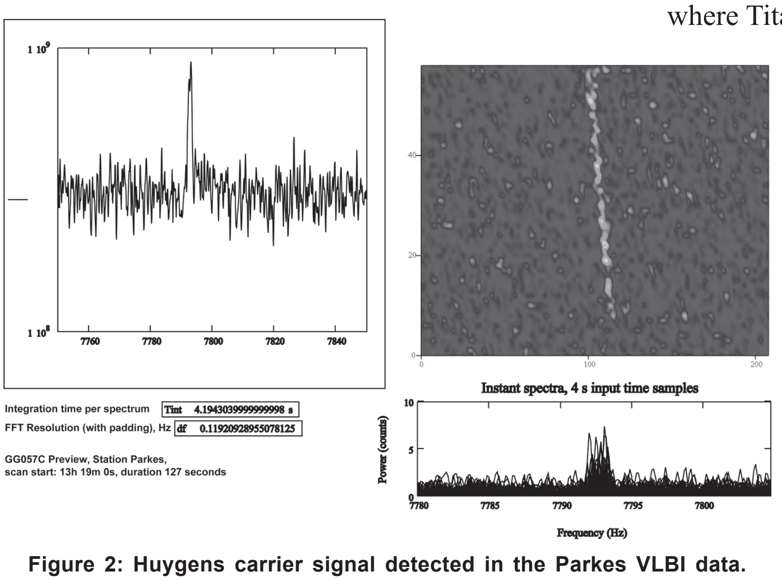

Figure 2: Huygens carrier signal detected in the Parkes VLBI data. Plots – courtesy Sergei Pogrebenko, JIVE.

We would like to thank everyone who has been involved in the LBA observations of the Huygens descent onto Titan. This has been a large and complicated experiment and would not have been successful without the hard work of many people.

Chris Phillips and Tasso Tzioumis (Chris.Phillips@csiro.au, Tasso.Tzioumis@csiro.au)

Parkes tracking of the Huygens probe

As well as playing a major role in the VLBI tracking of the Huygens probe, Parkes was involved in a second complementary experiment, the "Doppler Wind Experiment" (DWE), coordinated by the Jet Propulsion Laboratory (JPL, USA). This experiment involved using the Greenbank (USA) and Parkes radio telescopes to detect the Doppler shift of the Huygens 2040-MHz carrier signal in real-time. From the Doppler-shift measurements the line-of-sight velocity of the probe could be determined. The data from the DWE and VLBI tracking will be combined to allow a more comprehensive understanding of the direction and strength of the zonal winds of Titan's atmosphere.

For the first part of the descent, the Huygens probe was visible from Greenbank while the second part was visible at Parkes. However, twenty minutes before the probe was scheduled to land, it set at Greenbank. At Parkes, the expected landing time of the probe was just four minutes after it was scheduled to rise above the local horizon.

Inside the Parkes control room the team set about calmly preparing for the track. Dion Lewis, checked and double checked the VLBI recording equipment and cleared lots of disk space for the expected flood of data. John Reynolds performed numerous focus and pointing checks of the receiver, fine-tuning the system to get the strongest possible signal. Jim Border and Doug Johnston, engineers from JPL, set up their equipment and established a continuous telephone link to JPL's mission control in Pasadena.

When Huygens entered the atmosphere of Titan, the giant Greenbank telescope in West Virginia, USA, was poised to detect the signal when the transmitters sprang to life. Right on schedule at 9:18 pm (AEDT), Greenbank reported detecting the signal. A quiet cheer went up in the Parkes control room – we knew we had a mission.

Both Greenbank and Parkes were equipped with spectrum analysers that allowed them to see the signal as a small spike in the pass-band of the receiver. It was this spike that Greenbank reported seeing. At Parkes, Doug Johnston had the capability to further process the data to produce plots of the carrier's Doppler-shift variations. The radio science receivers at Greenbank and Parkes were capable of measuring the Doppler shift of the signal in real-time. Doug could compare these to the predicted Doppler shifts based on a smooth atmospheric descent model. Any variation from these predictions was an indication of winds in the atmosphere of Titan. Within just three minutes of the initial signal reception, Doug transferred the Greenbank data over the JPL network and processed it at Parkes. The difference between the real and predicted Doppler shifts was plotted. This showed that the probe was deviating significantly from the expected descent profile. At first the detected signal was just 35 Hz off the predicted value, but as it descended further, the deviations increased and fluctuated. The winds on Titan were much stronger than expected. It was an amazing feeling to realise that we were the first people ever to "see" the winds of Titan.

At 9:32 pm Doug reported seeing the glitch in the Doppler shift that indicated the main parachute had deployed on schedule.

Meanwhile, the tension at Parkes was quietly rising as the time slowly approached for Parkes to take over. One hour before the beginning of the track, John Reynolds switched over to the generator to prevent an unforseen power loss from disrupting the track. At 11:12 pm the Parkes dish was slewed over to the horizon to wait for Titan to rise. At the same time the probe set at Greenbank.

As the minutes ticked by, we all gathered in front of Doug's console waiting for the beginning of the track and confirmation that we were receiving the signal. Right on schedule at 11:29 pm the dish began tracking and the signal appeared on the spectrum analyser. The signal was 4 dB or 2.5 times stronger than expected.

Doug had been viewing the plot of the Doppler shift variations, which only showed glitches when it departed from the predictions. Jim Border, decided to plot the sky frequency, that is, the actual frequency received. Sure enough, there was a large glitch at the suspected landing time of 11:45 pm. This confirmed the landing of the probe on Titan. Shortly after midnight, Jim and Doug alerted JPL and ESOC and the word quickly spread around the world that the probe had landed. Cheering erupted in the control room and congratulations were exchanged. The landing had been a much softer touchdown than expected and occurred sometime between 11:45 and 11:46 pm, 12 or 13 minutes later than expected. It was a second moon landing for Parkes.

The dish continued to perform flawlessly throughout the track until at 2:56 am Huygens finally set at Parkes, still transmitting strongly. The champagne was duly popped open in celebration. For this moon landing, the high winds were thankfully on Titan and not at Parkes.

For photographs of the event see: *www.parkes.atnf.csiro.au/events/huygens_track/*

John M Sarkissian, Operations Scientist (John.Sarkissian@csiro.au)

Astrofest 2004

The annual Astrofest was held at Marsfield on 8 December 2004. With 14 engaging presentations on a wide range of topics, the day was interesting and educational for all. The day was kicked off to a scintillating start by Lucyna Kedziora-Chudczer and Jim Lovell, who both presented interesting new results on interstellar scintillation. This was followed by a brief foray out of the Milky Way by Eric Wilcots, looking at the nature of lopsided galaxies. After morning tea we learned of recent developments in pulsar research at Parkes from George Hobbs, Aris Karasteriou and Joel Weisberg. Joel presented the first ever detection of maser emission stimulated by a pulsar. It was evident when it came to question time that the minds of many people in the audience were racing to consider the exciting possibilities for follow-up studies.

After lunch it was time for extragalactic astronomy again, with discussions of current major survey projects by Ray Norris (Compact Array deep field), Lister Staveley-Smith (ALFA deep field) and Baerbel Koribalski (LVHIS). Wilfred Walsh provided much needed further input to the question of whether or not the fine-structure constant varies.

The final session began with a talk from Maxim Voronkov about new masers in GL2789, followed by Jim Caswell discussing the use of supernova remnant polarisation in determining the structure of the Galactic magnetic field. This was followed by Chiara Ferrai who told us about star formation in merging galaxy clusters. Tara Murphy rounded off the day with a discussion of the AT online archive, processing and visualisation systems. This stimulated a lively discussion of the technical and political aspects of virtual observatory projects. The proceedings were rounded off with cheese and biscuits.

Altogether a stimulating day of presentations. Thanks to everyone involved.

Russell Edwards and Juergen Ott (Russell.Edwards@csiro.au, Juergen.Ott@csiro.au)

Narrabri web scheduling tools and Miriad changes

Miriad has recently been upgraded to handle large files of more than 2 Gbytes or 2^{31} bytes in size. These changes are supported on Solaris, LINUX and MacOS, and possibly other UNIX variants. Miriad users who wish to handle large files at their home institutions or on their laptops will need to update their Miriad version using the standard update facility (mirimport).

To help observers prepare for, and schedule observations, two new tools are now available on the Narrabri web page: *www.narrabri.atnf.csiro.au/observing.*

These are:

- a tool to compute the sky frequency for a spectral-line observation given the line of interest, the observing epoch and the systemic velocity of the source;

- a tool to assist in determining the cycle time between observations of calibration sources.

Amongst other parameters, this cycle time depends on the phase stability of the atmosphere, the required dynamic range of the resultant image (i.e. the phase errors that can be tolerated), and whether self-calibration will be used.

Atmospheric phase stability is described by three parameters, all of which are measured by the Narrabri seeing monitor.

Bob Sault (Bob.Sault@csiro.au)

New Class-I methanol masers at 104.3 GHz and 9.9 GHz

The methanol molecule has a large number of maser transitions that can be observed with existing radio telescopes. Approximately 500 methanol maser sites are known in regions of massive star formation in the Galaxy. Interestingly, the behavior of different transitions is not the same. One group of transitions, the so-called Class-I methanol masers, is not associated with infrared sources and ultra-compact HII regions, while another group, the Class-II methanol masers, tends to be associated with them (Menten 1991).

The observed maser transitions for E-methanol (A- and E-methanol species have different spin orientations of hydrogen atoms) are shown on the energy level diagram in Figure 1. The sets of levels for different quantum numbers K are seen as "ladders" in this diagram. The Class-I maser transitions occur from the ladder with K = -1 to K = -2, from K = -1 to K = 0, and from K = 2 to K = 1, while the Class-II transitions occur from the ladder with K = -2 to K = -1, from K = 0 to K = -1, and from K = 1 to K = 0.

Theoretical calculations (e.g. Cragg et al., 1992; Voronkov 1999) have shown that an excess of collisional transitions (for example in a region of gas excited by an outflow, but away from the protostar) will lead to an over-population of the K = -1 and K = 2 ladders with respect to adjacent ladders, and so to the formation of the Class-I masers. Similarly, an excess of radiative transitions (as near an infrared source) under-populates the K = -1 ladder and over-populates the K = 1 ladder, switching on the Class-II masers. Note, that there are transitions of both classes between the ladders with K = 0 and K = -1, as well as between K = -1 and K = -2, but they occur in the opposite directions on the diagram. Such transitions should not co-exist in the same region of space as they require mutually exclusive physical conditions. However, a co-existence of transitions of different classes occurring between different ladders or belonging to different species of the methanol molecule may be realised in some cases. This is a subject of the ongoing theoretical and observational research (Voronkov et al., 2004).

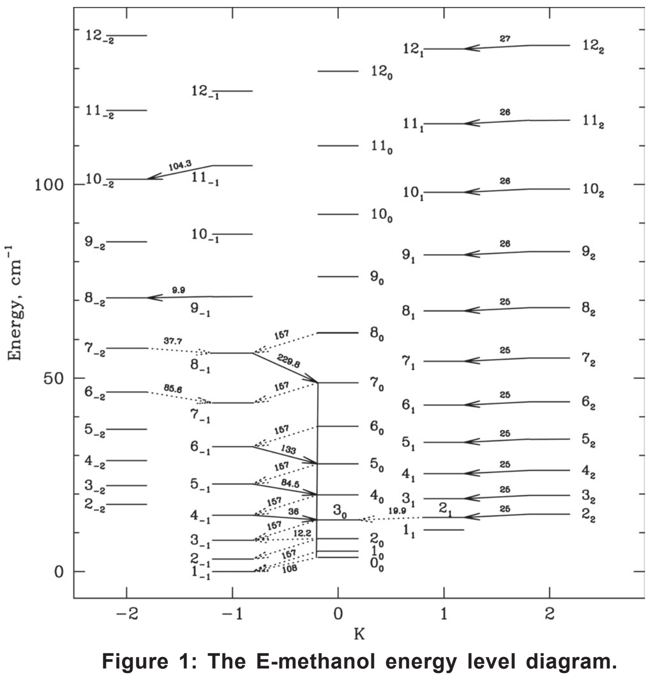

Figure 1: The E-methanol energy level diagram. Solid arrows represent known Class-I maser transitions, dotted ones represent known Class-II maser transitions. The numbers near each transition are their frequencies in GHz.

Another problem which is still unsolved is to create an accurate quantitative model of the Class-I masers. Flux density predictions provided by existing models of these masers are very crude and do not allow one to get a reliable estimate of the physical conditions. To put useful constraints on the maser model, simultaneous observations of many maser lines are required. The Compact Array will play a significant role in this research because many Class-I methanol maser lines fall into an observable frequency range. When completed, this study will provide an indirect measurement of the physical conditions such as the temperature and density in the regions of interaction between outflows and the ambient material, which the Class-I methanol masers are believed to be associated with. A difficulty however, is that bright masers in some transitions are rather rare, and a preliminary search is required to choose good targets for studying multiple transitions. Only one narrow-line maser was known before the present study, with detections at both 104.3 GHz (Voronkov et al., 2004) and 9.9 GHz (Slysh et al., 1993) despite a comprehensive search at 104.3 GHz conducted in the Northern Hemisphere. In contrast, there are almost a hundred known sources at 44 GHz.

For a multi-transitional study it is reasonable to start with sources that have been detected in as many maser transitions as possible. However, some transitions, especially if their fluxes correlate with each other, may not add new information and, hence, a new constraint. In general, such correlations may be expected for transitions that belong to the same series. Therefore, the properties of different transitions should be examined carefully on the same sample of sources.

We have used the ATNF Mopra antenna to search for the 104.3-GHz masers towards the 44-GHz Class-I masers found in the Parkes survey (Slysh et al., 1994)

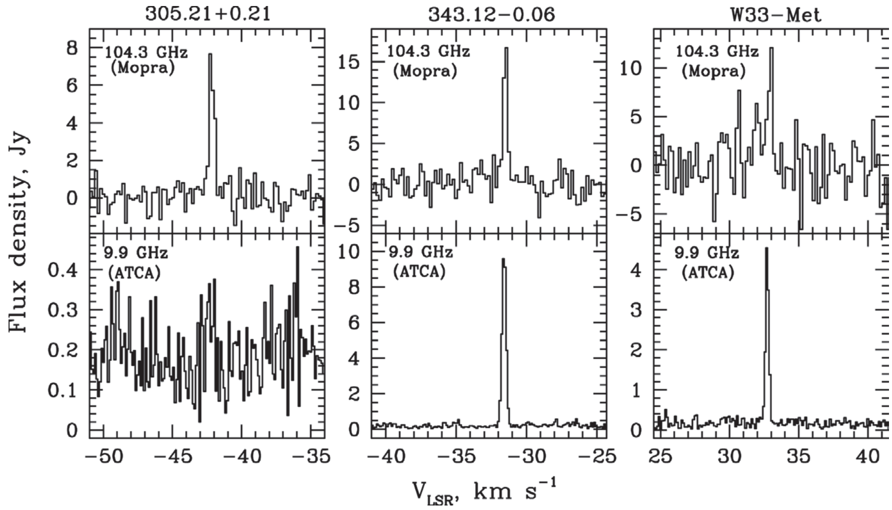

Figure 2: The 104.3-GHz and 9.9-GHz spectra of the new detections and W33-Met, the only previously known narrow-line maser at these frequencies.

with a typical detection limit of a few Jansky. Narrow-line maser emission was detected towards G305.21+0.21, G343.12-0.06 and W33-Met, the only previously known source. Their spectra are shown in Figure 2. We also detected broad-line emission from G327.29-0.58, G351.41+0.64 and G351.78-0.54 and marginal detections from five sources, G0.54-0.85, G14.33-0.64, G328.809+0.63, G344.23-0.57 and G345.00-0.22.

In follow-up observations, we have recently found that the Compact Array has a reasonable sensitivity at 9.9 GHz (except antenna 1), although this frequency is beyond the nominal frequency range of 8.0 to 9.2 GHz. We have used the Compact Array for 9.9-GHz observations of the sources with definite maser detections at 104.3 GHz. The 9.9-GHz spectra are also shown in Figure 2.

For G343.12-0.06, the uv-coverage of the Compact Array observations was good enough to construct an image showing a point source at RA (2000) = 16:58:16.57 and Dec (2000) = -42:52:24. In contrast, W33-Met has a complex spatial structure at 9.9 GHz despite a simple spectrum. The current uv-coverage is not sufficient to construct a reliable image. A complex spatial structure is consistent with the 104.3-GHz and 9.9-GHz spectra of W33-Met (Figure 2), which have emission peaks at different velocities. For G305.21+0.21, the 9.9-GHz line was not detected at a significant level with the Compact Array.

A comparison of the 9.9-GHz and 104.3-GHz spectra brought some surprises. First, the flux ratio changes significantly despite the fact that these two masers belong to the same transition series J_{-1}-$(J-1)_{-2}E$. Numerical simulations are required to understand which parameters this flux ratio is sensitive to. In contrast to this pair, the fluxes of the 44-GHz and 95-GHz A-methanol transitions, which are widespread and belong to another series, J_0-$(J-1)_1A^+$, are known to be correlated (Val'tts et al. 2000). This makes one of them redundant for determination of the physical conditions. Second, the 104.3-GHz line (J = 11) appears to be brighter than the 9.9-GHz line (J = 9), which has a lower excitation energy. This shows that even within the same ladder the population distribution is far from the equilibrium, and, hence, should depend on the pumping mechanism. This, together with the relative rareness of these lines makes the J_{-1}-$(J-1)_{-2}E$ series a promising tool to diagnose maser pumping.

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Software for the Virtual Observatory at the ATNF

In the last two years, the ATNF has contributed to the Australian Virtual Observatory (*www.aus-vo.org*) and the International Virtual Observatory Alliance (IVOA) (*www.ivoa.net*). Several ATNF VO projects are now near completion.

Australian Telescope Online Archive

The Compact Array data archive is now available online at *www.atnf.csiro.au/atoa*. See the separate report on page 13.

Compact Array pipeline data reduction

The ATOA holds unprocessed visibility data (RPFITS files). We have developed a pipeline that can automatically process the data selected from the archive, to generate FITS images. The pipeline runs on an ATNF computer – this means that a user does not need to download anything except the final images (and other intermediary data products). If required, images can be displayed with the Remote Visualisation System (RVS) before they are downloaded.

The pipeline was developed in collaboration with CSIRO ICT Centre in Canberra. The ICT Centre developed software to "reverse engineer" the intent of an observer from the raw data. This process is used to determine which sources are calibrators and which are targets and the associations between calibrator and target sources. This is an essential and non-trivial process for an automatic pipeline. The ICT Centre also developed the web services layer of the system.

The pipeline data reduction is currently restricted to fully automatic processing of single-pointing continuum data. We are in the process of extending this to include spectral-line processing and later on will include multiple-pointing data. We are also developing a Graphical User Interface (GUI) so that users can have some control over the processing components.

The pipeline uses aips++ modules and is accessed via web services.

Remote Visualisation System

Issue 53 (June 2004) of the ATNF News discussed the RVS in detail. This activity was initiated as a research project to examine a generic framework for VO applications. After the first year of development, we proceeded to use the new framework to deliver an end-user service: RVS.

The RVS is a distributed server-side system that renders (as a raster or contours) an astronomical FITS image and displays the rendered image to the user's desktop. Its current niche is in astronomical archives; the RVS server has a high bandwidth connection to an image archive and allows a user to browse and display images from the archive without downloading them to their own computer. Once the image archive data have been inspected and images selected, the images can then be downloaded.

RVS helps this process because the visualised images are only a few tens of kilobytes in size, so browsing the archive is quick and easy, even over low-bandwidth connections.

RVS also provides integration with other IVOA tools by allowing a user to:

- make Simple Image Access Protocol (SIAP) queries. These return a FITS image which RVS renders and displays (for example as a contour overlay);
- make ConeSearch queries. These return a list of source locations which RVS will overlay on the image display.

RVS is built with Java, SOAP, CORBA and its visualisation is provided by the aips++ Display Library. To run this application, Java and Java Web Start are required on the local desktop.

The first applications of the RVS are now in use with the data archive for the Southern Galactic Plane Survey (*www.atnf.csiro.au/research/sgps*) data archive and the HIPASS data archive (*www.atnf.csiro.au/research/multibeam/release*).

ATNF image archive back-ends and IVOA queries

There are a number of image archives either provided by or hosted by the ATNF. Most of these have been put together by the team of the particular project, with custom back-end software to provide access to the data. We are in the process of unifying the back-ends of some of these image archives via a common software infrastructure. This will make it easier to bring new archives online and reduce ongoing maintenance.

At the same time, this software infrastructure (built with aips++ modules) will be used to serve data to IVOA queries such as SIAP and Simple Spectral Access Protocol (SSAP). These protocols enable a user to query an image archive and return back a FITS image or spectrum.

This work will be completed in the next couple of months.

Web services

There are many fundamental (but often complex) computational services that astronomers need. For example, conversion of a frequency between different reference frames. The ATNF is bringing together a range of these common services (built with aips++ modules). These will be provided via an HTML page and also as a web service application. The latter means that a user can write a piece of software and then request the web service to perform some computation.

The basic services that will be provided are:

- unit conversion;
- coordinate conversions between different reference frames; and
- conversion between frequency and velocity.

In addition to the basic infrastructure the web service will provide some higher-level applications available in the GUI. One example is a task to calculate the rise and set times for a specified source and location.

The team

The people who have contributed to the ATNF VO effort are Anil Chandra, Jessica Chapman, Nadia Davidson (ATNF vacation student), Neil Killeen, Malte Marquarding, Dave McConnell, Vince McIntyre, Tara Murphy, Chris Owen and Praveena Tokachichu.

For more information on the ATNF VO work, please refer to *www.atnf.csiro.au/vo*, or email Tara Murphy (*Tara.Muphy@csiro.au)* or Malte Marquarding (*Malte.Marquarding@csiro.au)*.

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Australia Telescope Online Archive

The last edition of ATNF News (issue 54), included a report on the development of the Australia Telescope Online Archive (ATOA). This is an archive of raw data files, compiled from Compact Array observations taken since 1990. These data can now be directly downloaded via a web interface.

The archive currently provides access to data files recorded on or before 31 December 2004 and will be updated approximately every month. At present the archive is updated by transferring files from Narrabri to Marsfield on DLT tapes. We expect to replace this soon with an automated “trickle” process where data files are directly transferred to the Marsfield disks over the network.

The ATOA was released on 3 December 2004 and should be functional with the browsers Mozilla 1.0+, Firefox 1.0+, Internet Explorer 6, Netscape 7.0+, Konqueror or Safari. Other browsers and versions may also work but are not supported by the ATNF.

So far, good use has been made of the archive with 184 data downloads from 39 different users between the release date and the end of January 2005. This is a significant increase over the previous system when archive requests were received by email and the data provided on CDs.

We request that any publications that make use of ATOA data should acknowledge the ATOA. For appropriate words to use please refer to the web page *www.atnf.csiro.au/research/publications/.*

The ATOA is available at the web address *www.atnf.csiro.au/atoa*. Any comments or fault reports on the use of the archive are most welcome.

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Shame about Shain! Early Australian radio astronomy at Hornsby Valley

Introduction

Between 1946 and the early 1960s, pioneering scientists based at a number of different field stations near Sydney were responsible for building Australia's reputation as a world leader in the new field of radio astronomy (see Orchiston and Slee, 2005). One of these was Alex Shain. Charles Alexander Shain was born in Melbourne on 6 February 1922, and after completing a B.Sc. degree at the University of Melbourne and serving briefly in the military, he joined the CSIR's Division of Radiophysics in November 1943. During the war he worked on the Division's radar program and in the immediate post-war years championed "low frequency" radio astronomy in Australia, first at Hornsby Valley field station and later at Fleurs. When Shain died on 11 February 1960, Australia lost one of its pioneers, and its leading authority on decametric radio emission. Pawsey (1960:245) described Shain as "… a wonderful colleague in the laboratory, imaginative, well balanced, exceedingly unselfish, and a real friend to all". In this article we review his work at Hornsby Valley.

Hornsby Valley field station

The picturesque Hornsby Valley field station (Figure 1) was located on farmland in a quiet valley to the west of the Pacific Highway, and between 1947 and 1952 was home to a number of unusual radio telescopes. Under the auspices of Frank Kerr, Ruby Payne-Scott, Alex Shain and Charlie Higgins these were used to carry out pioneering studies in lunar, solar and galactic astronomy.

Figure 1: Panoramic view of the Hornsby Valley field station in 1952, showing antennas and an instrument hut.

The first research conducted at this field station was in radar astronomy: in 1947 – 1948 Kerr and Shain spent a year bouncing signals off the Moon in order to investigate the structure of the upper ionosphere. A rhombic aerial linked to a modified communications receiver recorded the bounced signals (Figure 2), which were broadcast at 17.84 and 21.54 MHz by Radio Australia from Shepparton in Victoria. Thirty different experiments were carried out, and echoes were received on twenty-four occasions; as expected, these provided further information about the Earth's ionosphere, but from an astronomical viewpoint the interesting conclusion that Kerr and Shain drew was that the nature of the echoes showed the Moon's surface to be "rough" rather than smooth (Kerr & Shain, 1951). Kerr then transferred to Potts Hill (where he went on to make a name for himself through his H-line work).

Figure 2: The antennas and instrument huts used for the Moon-bounce project.

Payne-Scott moved to the Hornsby Valley towards the end of 1947 with the intention of expanding the solar work she had begun at Dover Heights. She set up 60, 65 and 85-MHz Yagis, and from January through to September 1948 used these, the Kerr-Shain Moon-bounce rhombic antenna and an 18.3-MHz broadside array to study solar bursts before she also transferred to Potts Hill field station.

With Payne-Scott and Kerr gone, Shain and Higgins were able to develop Hornsby Valley into the Radiophysics Division's forefront "low frequency" field station. In 1949, they erected an array of eight half-wave dipoles strung between four rows of telegraph poles with the ground serving as a reflector, and used this novel radio telescope to investigate galactic emission at 18.3 MHz (Shain, 1951). The antenna system was attached to a standard communications receiver, and observations were carried out between May and November 1949. The success of these early observations led Shain and Higgins to expand the array to 30 horizontal half-wave dipoles, so that a more detailed survey could be carried out with a smaller beam. Although the antenna was stationary it was possible to move the beam electronically, and this meant that a wide strip of sky from declination –12° to –50° could be surveyed (Figure 3). The observations were carried out between June 1950 and June 1951, and only about 10% of all records were unusable through interference or atmospherics (Shain, 1954).

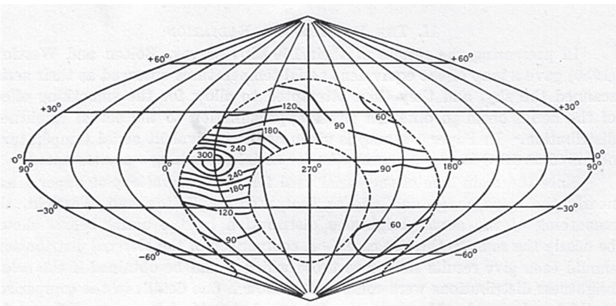

Figure 3: Galactic co-ordinate plot of continuum emission at 18.3 MHz (after Shain 1954: 152).

In June 1951 the 18.3-MHz radio telescope was replaced by a network of 12 fixed horizontal half-wave dipoles, operating at 9.15 MHz. This utilised some of the original telegraph poles, in four parallel banks each of three dipoles. The array was attached to a standard communications receiver. Like its predecessor, this was a transit instrument which relied on the Earth's rotation in order to record radio emission from different strips of the sky (but this time without directing the beam). Once again, Sydney's fortuitous latitude meant that the celestial region of greatest interest, the Galactic plane and centre of the Galaxy, would pass almost directly overhead. Between July 1951 and September 1952 this radio telescope was used by Shain and Higgins to scan a strip of sky centred on declination –32° (Higgins and Shain, 1954). It was in August 1952, during this research project, that some of the delegates from the URSI Congress — which was meeting in Sydney — visited Hornsby Valley and were given a guided tour of the site (see Figure 4).

After completing the 9.15-MHz survey, Shain planned to embark on a major new decametric project, but he concluded that "The Hornsby station will not be satisfactory … [due to] lack of adequate open level space … Hence we should plan to progressively evacuate Hornsby – breaking down the gear now in use after October 1952." (Shain, 1952). While Shain suggested Badgery's Creek as a suitable site for the new "low frequency" work, it was in fact Fleurs that benefited from the eventual close-down of the Hornsby Valley field station in 1955, acquiring the

Photo credit: ATNF: 2842-131

Figure 4: Radio astronomers from the 1952 URSI Congress at Hornsby Valley. Shain is on the extreme left, seated between Hanbury-Brown and Graham Smith while Higgins, in the dark jacket, is sitting opposite him.

distinctive 19.7-MHz Shain Cross (see Orchiston and Slee, 2002). This was completed in 1956, but Shain was only able to enjoy this new facility for four short years before cancer brought a premature end to his life.

The "Lost Opportunity"

There is one fascinating post-script to this story. A common Hornsby Valley problem at 9.15 and 18.3 MHz was terrestrial interference—which Shain and Higgins tended to dismiss as rather a nuisance—but when Burke and Franklin reported the discovery of decametric burst emission from Jupiter in 1955 they were forced into a rethink. When he revisited some of those periods of "intense static" recorded at 18.3 MHz in 1950 and 1951 (see Figure 5), Shain found that these were indeed Jovian bursts, and this serendipitous "pre-discovery" proved to be one of RP's most notable "lost opportunities". Shain (1956) noticed that the bursts were not uniformly distributed in Jovian longitude but tended to cluster between 0° and 135°. In other words, much of the radiation appeared to derive from a localized region on the planet, and its rotation period was 9h 55m 13±5s, marginally longer than Jupiter's

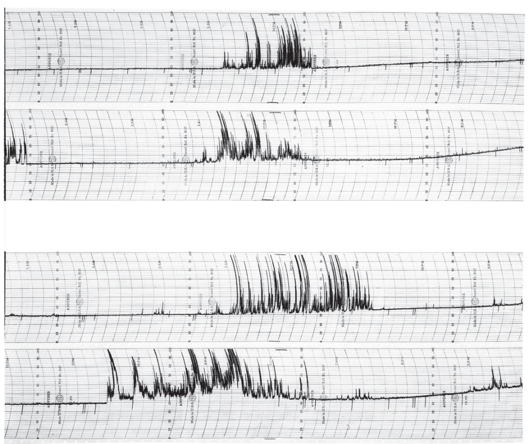

Photo credit: ATNF: B3719-13

Figure 5: Examples of 18.3-MHz Jovian bursts noted on the 1950 – 1951 Hornsby Valley chart records.

System I rotation period. Only later would we come to associate Jovian decametric emission with the magnetic torus linking Jupiter and its enigmatic inner moon, Io.

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CSIRO postgraduate scholarships

It is a pleasure to announce that the recipients of the 2005 CSIRO Postgraduate scholarships are Adam Deller and Emil Lenc, both at the Swinburne University of Technology. Adam will be working with Steven Tingay (Swinburne) and John Reynolds (ATNF) on eVLBI technology development. Emil is also working with Steven Tingay and with Tasso Tzioumis (ATNF) on widefield, high-resolution imaging techniques as applied to radio galaxies. Congratulations to both Adam and Emil! The prestigious CSIRO Postgraduate scholarships are awarded annually to exceptional students beginning their PhD. Applications are due at the same time as APA applications.

Interested students should see *www.atnf.csiro.au/education/graduate/csiro_scholars.html* for more details.

Naomi McClure-Griffiths
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Distinguished Visitors program

Current long-term visitors are Joel Weisberg (Carleton College, USA, visiting until June 2005) and John Storey (UNSW, visiting until December 2005).

Future visits are expected from Tam Helfer (UC Berkeley, USA), John Lugten (UC Berkeley, USA), Michael Kramer (Jodrell Bank, UK), Busaba Kramer (NECTC, Thailand), Mary Putman (U Michigan, USA), and Jayaram Chengalur (NCRA, India) and Ken Johnston (USNO).

Prospective visitors should discuss working visits with the Director, a staff collaborator or myself.

Lister Staveley-Smith
on behalf of the DV committee
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ATNF graduate student program

We'd like to introduce three new students who have recently started PhD projects with ATNF co-supervisors:

- Alyson Ford (Swinburne Univ) has started her project "GASS: The Galactic All-Sky Survey" with supervisors Prof Brad Gibson (Swinburne) and Dr Naomi McClure-Griffiths (ATNF).
- Emil Lenc (Swinburne Univ) has started his project "Studies of Radio Galaxies, Starburst Galaxies, and Gravitational Lenses using Widefield, High Spatial Resolution Radio Imaging" with Dr Steven Tingay (Swinburne) and Dr Tasso Tzioumis (ATNF).
- Leith Godfrey (RSAA, ANU) has started his project "Dynamics of Large-Scale Extragalactic Jets: A multiwavelength Study of X-ray Bright Jets" with Dr Geoffrey Bicknell (RSAA) and Drs Jim Lovell and Dave Jauncey (ATNF). Leith is also the recipient of a CSIRO top-up scholarship (see related item).

We also congratulate Daniel Mitchell on the successful defence of his University of Sydney PhD thesis, "Interference Mitigation in Radio Astronomy" and hope that the techniques he's developed will be widely put into practise in the coming years!

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AT Users Committee meeting report

The most recent meeting of the Australia Telescope Users Committee (ATUC) was held on 9 – 10 December 2004, at the ATNF headquarters in Marsfield. This was the last meeting for several ATUC members, Naomi McClure-Griffiths, Maria Hunt (regular members) and Bradley Warren (student member). On behalf of the ATNF user community I'd like to thank Naomi, Maria and Bradley for their efforts and input into ATUC during their terms. Also in December, ATNF overseas users were formally represented at ATUC for the first time by Adam Burgasser from the American Museum of Natural History in New York. From now on at each ATUC meeting, overseas users will be represented by an observer visiting from overseas.

ATUC were particularly impressed with a number of ATNF projects that have achieved notable milestones or levels of success, in particular: the deployment of the full 3-mm system on the Compact Array and the prospects for its first full-winter season; the success of the e-VLBI project in its progress toward a real-time, high bandwidth VLBI network; and the Australia Telescope Online Archive, which looks fantastic and likely to greatly boost the scientific output of the ATNF.

The full report from the December ATUC meeting is currently available on the ATUC website (*www.atnf.csiro.au/management/atuc*), along with an archive of supporting documents that were used at the ATUC meeting. The meeting report should be referred to for full details of all the agenda items. Some of the more substantive issues that were covered at the meeting were as follows:

- **Scheduling issues**

  Some users are concerned with the time delay between proposal submission and notification of the outcome of the TAC meeting. Usually notification to users of the outcome of their submitted proposals occurs only when the observing schedules are released or when they receive the hardcopy notification in the post. ATUC suggested that sending TAC comments and rankings in letters to proposal contact people via the regular post could be replaced by email notification. In the future, once the electronic proposal system has been developed, it would be useful if notification emails could be sent to a nominated list of the proposal co-investigators, rather than just a single contact person.

- **Competency of Compact Array duty astronomers**

  ATUC requested that more attention be paid to the quality and effectiveness of the Duty Astronomer service provided at Narrabri. Duty astronomers (DAs) are astronomers rostered from ATNF staff, students and the user community to provide support to observers at Narrabri for periods of one week at a time. In particular, ATUC suggested that astronomers who are undertaking DA duties for the first time should arrive earlier at Narrabri (on the Monday rather than the Wednesday) so that they can overlap with the previous DA, become familiar with their duties, and learn about any recent changes to the system or current problems, ahead of when their duty is scheduled to start. ATUC also suggested that once per year there could be an induction day(s)/weekend for new DAs or DAs who have not observed in Narrabri for a significant period of time.

- **Mopra 3-mm 8-GHz system**

  ATUC were asked to look at several options for the operation of the 3-mm system at Mopra in the 2005 and 2006 winter seasons and to give some feedback on which option would be preferable. Please refer to the full report on the web for the ATUC discussion on the various options that were considered.

In the near future, ATUC and the ATNF will aim to organise meetings for users to discuss the likely capabilities and scientific goals of a potential Compact Array 7-mm system and the capabilities and scientific goals of the NTD and xNTD projects. These meetings will likely take place in early to mid-2005. Announcements for the meetings may be made in the coming weeks.

Finally, if users have any comments on the content of the latest ATUC report, they can contact the ATUC Chair (*stingay@astro.swin.edu.au*). For more general comments and suggestions to ATUC, users should feel free to contact their local ATUC member (listed on the ATUC webpage) or submit comments online via the ATUC webpage.

Steven Tingay
ATUC Chair
(stingay@astro.swin.edu.au)

Articles

Discovery of a planetary nebula around the OH/IR star V1018 Sco

The OH/IR star

V1018 Sco (IRAS 17317-3331, OH354.88-0.54) is a well known OH/IR star with strong infrared and radio maser emission. The OH 1612-MHz maser spectrum of V1018 Sco, shown in Figure 1, has a double-

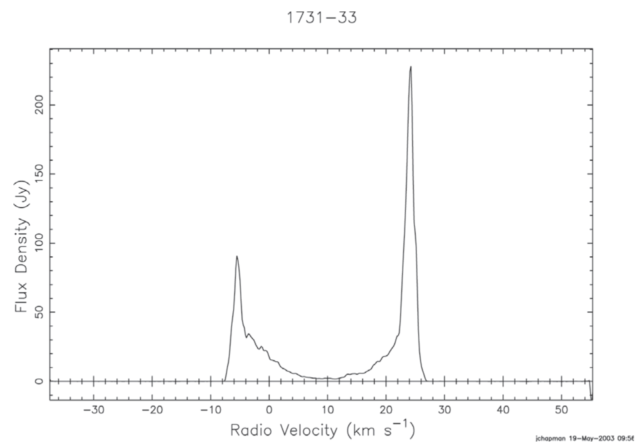

Figure 1: An averaged OH 1612-MHz spectral profile of V1018 Sco, from 36 separate epochs of observations at Parkes. The stellar velocity, determined from the centre of the profile is 9.4 km s^{-1} and the OH expansion velocity, determined from the separation of the peaks, is 14.9 km s^{-1}. The two emission peaks correspond to the strongest maser emission seen from the front and back of the expanding circumstellar envelope.

peaked profile that is characteristic of asymptotic giant branch (AGB) stars where the maser emission occurs from the outer regions of an expanding circumstellar envelope. Welty et al. (1987) have imaged the OH 1612-MHz maser emission with the VLA and shown that it occurs in a number of clumps distributed within a shell of angular diameter ~ 3.3 arcsec. The OH shell has strongest emission in an east-west plane and is weaker to north and south. We interpret this as a well-filled molecular torus around the star with less dense emission along a polar axis.

Figure 2 shows an OH light curve of V1018 Sco, obtained from 36 epochs of Parkes monitoring data, over a five-year period. The light curve shows that the star is a large-amplitude, long-period variable with an exceptionally long pulsation period of 1486 days. The light travel time across the OH envelope has been obtained using a phase lag technique (Chapman et al. 1995). The measured phase lag of 60 days corresponds to a linear size of the OH shell of 11,000 AU. The phase-lag linear diameter and the angular diameter yield a stellar distance of 3.2 kpc, with an estimated precision of about 20%.

The OH maser properties of V1018 Sco are characteristic of maser emission from an OH/IR star with a high expansion velocity (14.9 km s^{-1}), an exceptionally long pulsation period (1486 days) and an extremely large OH shell (11,000 AU). The large-amplitude pulsations demonstrate that the star is still pulsating strongly, and has not yet left the AGB stage of evolution, while the large shell size, long stellar period and Galactic location indicate a fairly massive star with an initial mass above 4 $M_{\odot}$.

Discovery of the planetary nebula

During a systematic search for Galactic Planetary Nebulae, as part of the MASH (Macquarie-AAO-Strasbourg-Hα) project (Parker et al. 2003), a survey exposure of field HA630 showed a faint almost circularly symmetric Hα nebula. Subsequent identifications showed that the position of the centre

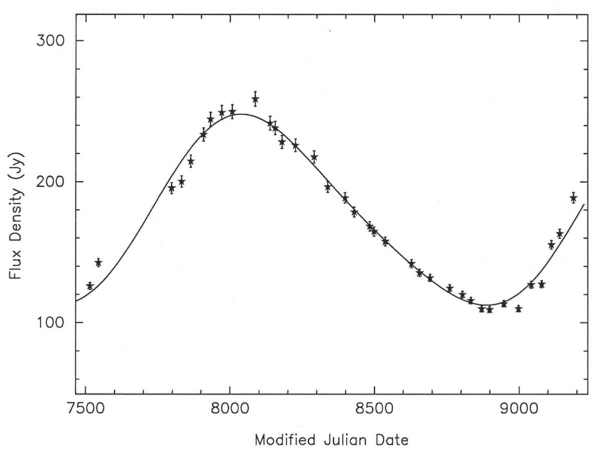

Figure 2: The OH 1612-MHz light curve from the Parkes monitoring data, plotted using a weighted average of the emission from the blue-and red-shifted emission peaks. The best-fit curve for a period of 1486 days is also shown. This is obtained assuming a combination of a fundamental period and a single harmonic.

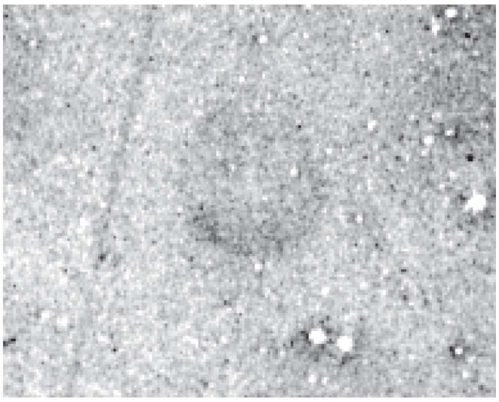

Figure 3: The weak circular feature at the centre of the image shows an Hα ring, centred on the stellar position, detected as part of the MASH survey for planetary nebulae. The image size is 128 arcsec in declination and 140 arcsec in right ascension. To enhance the faint nebula, the image shown is a quotient image formed from the ratio of the Hα image to a short-red exposure of the same region. This effectively removes most of emission from point sources in the region.

of the nebula aligns precisely with the central position of the OH 1612-MHz masers. This position also coincides with a strong infrared source, detected as a point source in the MSX and IRAS mid-far infrared surveys. The nebula, shown in Figure 3, has an outer diameter of 39 arcsec, approximately 10 times larger than the OH shell. Follow up long-slit spectroscopy confirmed the presence of the nebula with the detection of Hα, [NII] and [SII] emission lines, typical of planetary nebulae.

Radio continuum and H_2O maser emission: first results

Following a target-of-opportunity request, in January 2004 we observed V1018 Sco at 3 and 6 cm using the ATCA for ~ 8 hours in the 6A configuration. Radio continuum was detected at both 3 and 6 cm with total flux densities of 0.5 and 2.2 mJy respectively, corresponding to spectral index of –0.8. The radio continuum thus appears to be strongly non-thermal. The brightest continuum emission is seen at both 3 and 6 cm as an arc-like extended feature located 14 arcsec southwest of the stellar position, on the inner edge of the optically visible nebula. To better define the radio continuum structure and to look for weaker, more extended emission, further radio continuum observations at 3, 6, 13 and 20 cm are in progress.

More recently, in November 2004 we obtained a detection of H_2O maser emission from V1018 Sco, from a short Compact Array observation. The spectrum shows two maser emission features at velocities of –2.4 and +25 km s^{-1} (Figure 4). In AGB

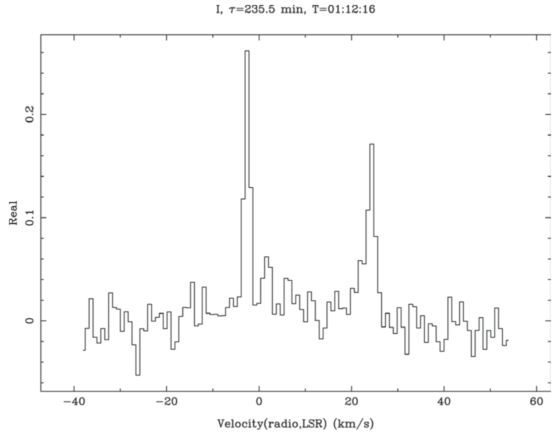

Figure 4: A spectrum of the 22-GHz water maser emission from V1018 Sco, obtained from a short observation taken with the Compact Array on 14 November 2004.

stars, the water masers are collisionally excited in the inner, denser regions of the circumstellar shells, at densities up to 10^{11} cm^{-3}. In general the water masers are located closer to the stars than the OH masers. However, for a small number of post-AGB stars, high velocity water maser emission has been detected that is associated with high-velocity, collimated molecular outflows. In such cases the water masers may be located beyond the OH maser region. An excellent example of this is seen in the AGB star W43A (Imai et al. 2002). Such jet-like flows may mark the beginning of the transition of an AGB star to becoming a planetary nebula, and play an important role in shaping the planetary nebulae.

Discussion

The detection of an ionised planetary nebula around a still-pulsating AGB star is remarkable. V1018 Sco is the only known source where a planetary nebula has been detected around an AGB star that is still pulsating and thus still in the AGB stage of evolution. AGB stars are the precursors of planetary nebulae. Models of stellar evolution predict that towards the end of the AGB phase, stars lose so much mass from their outer envelopes that they can no longer support strong pulsations. As a star evolves away from the AGB, the pulsations cease and the star changes from losing mass in slow dense winds to losing mass in a hotter, faster wind. During the post-AGB phase, the hot winds sweep up the remnant material and the swept-up shells become visible as planetary nebulae as the central stars become hot enough to ionise the shells.

In V1018 Sco we may be witnessing a hitherto unobserved phase where a planetary nebula has just started to form around an AGB star. We speculate that a fast wind has recently turned on and is able to penetrate lower density regions in the cooler AGB wind. For this scenario, collisional excitation may occur in accumulated material, previously shed during the AGB phase, far out in the circumstellar envelope. The continuum emission may occur from the wind-wind collision between the jet-like outflow and the cooler AGB wind, while the water masers may be associated with the jet, with the maser emission either from a post-shock region at the end of the jet, or from within the jet.

The optical, infrared and OH maser properties of V1018 Sco are discussed in more detail in a recent paper (Cohen et al. 2005). A second paper that includes the radio continuum and water maser emission results is in progress.

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Discovery of pulsed OH maser emission stimulated by a pulsar

Continued from page 1

spectrum appears at first glance to be merely a copy of the pulsar-*off* spectrum, shifted upward by a constant equal to the broadband pulsar signal strength. However, when these two spectra are carefully differenced to create the pulsar spectrum, it is clear that there is excess signal at the line frequency during the pulse – the broadband pulse signal has been amplified by stimulated emission at this frequency. It has long been assumed that stimulated emission plays an important role in astrophysical OH line radiation because it can be shown that the emitting clouds are not in local thermodynamic equilibrium. However, ours are the first measurements *directly* demonstrating the stimulated amplification of a signal propagating through the interstellar medium, in that the amplification is directly observable as the pulsar cycles on and off. Since this stimulated emission is driven by the pulsar pulse, it varies on a few millisecond timescale, which is orders of magnitude shorter than the quickest maser variations previously detected. The optical depth of the pulsed maser line is –0.05, implying that approximately five excess line photons are stimulated in the cloud for every hundred passing through it. Note that this amplification must occur for *any* signal propagating through the cloud at this frequency, but it is the pulsed nature of the pulsar signal that enables us to explicitly detect the excess photons generated by the stimulated emission process.

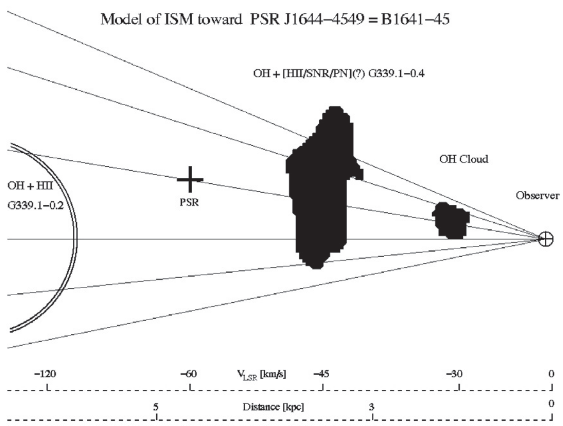

Figure 2: A schematic model of the ISM toward PSR B1641-45. The lines represent various lines of sight within the Parkes beam.

Pulsar B1641-45 lies in the inner Galaxy near the galactic plane, at (l,b) = (339.2, -0.2). There are a variety of complementary measurements of this region which we have combined with our observations to create a map of the ISM along the line of sight (see Figure 2). The distances are derived from kinematic analyses of radial velocity measurements, using a flat galactic rotation model. Note especially the two HII regions lying in this direction, G339.1-0.2, and G339.1-0.4.

Figure 3 displays spectra toward PSR B1641-45 at the four 18-cm OH lines. Pulsar-*off* spectra are shown in the left column while pulsar spectra are displayed in the right column. We see a strong line at v_{LSR} ~ –45 km/s in all eight spectra. The line is in absorption at 1612, 1667, and 1665 MHz and in emission at 1720 MHz (the latter being the maser line discussed above). This line must arise in gas lying between the pulsar and Earth, since it is visible in the pulsar spectra. It presumably occurs in OH gas associated with or near G339.1-0.4 since its radial velocity is similar to the HII region's. We see another OH line at v_{LSR} ~ –30 km/s in most of our spectra including the 1665 and 1667 pulsar spectra. This line must therefore also originate in gas nearer than the pulsar to us, also probably associated with or near G339.1-0.4. Note also that all pulsar-*off* spectra exhibit lines at v_{LSR} ~ (–100 to –120) km/s, which are not seen in the pulsar spectra. Therefore they originate in gas beyond the pulsar, which is probably associated with or near G339.1-0.2.

Another interesting phenomenon is also visible in Figure 3. Note that each 1720-MHz spectrum (top row) is an inverted copy of the 1612-MHz spectrum (second row). This phenomenon, dubbed "conjugate" line behavior, is frequently seen in interstellar OH clouds. It results from the initial states of both transitions being overpopulated by an identical physical process, so that the degree of overpopulation is also the same in both. We will be able to derive column densities of the clouds from comparison of the conjugate lines, since the details of the process are density-dependent.

Finally, note that the pulsar spectra (Figure 3, right column) exhibit much stronger absorption and stimulated emission than do the corresponding pulsar-*off* spectra (Figure 3, left column) at the same velocities. A similar discrepancy between pulsar and pulsar-*off* spectra was observed in the only other successful pulsar OH absorption experiment. Our new observations strengthen the earlier interpretation that this is a solid-angle effect. Apparently the tiny interstellar column sampled by the pulsar signal possesses significantly different properties from the medium sampled in the pulsar-*off* spectrum, which averages across the entire Parkes beam.

Presumably the pulsar pulse is encountering a small, dense OH cloudlet whose properties are diluted in the beam-averaged pulsar-*off* spectrum. This behaviour differs markedly from HI, where absorbing columns

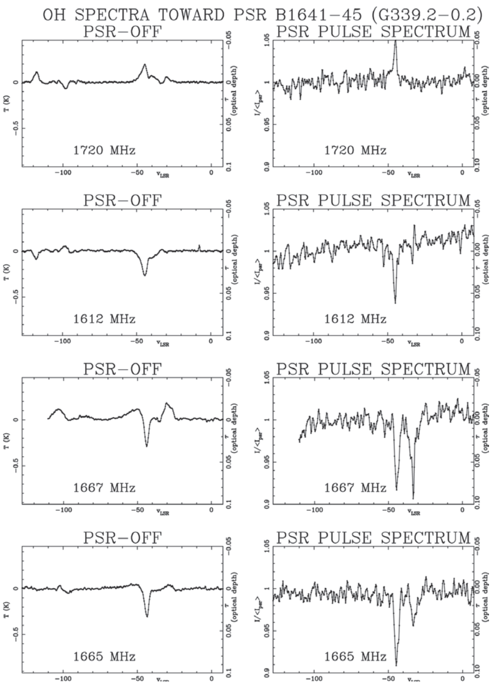

Figure 3: Spectra of the four 18-cm transitions of OH toward pulsar B1641-45. The left column displays the four pulsar-*off* spectra, which are sensitive to all emission and absorption in the Parkes telescope beam when the pulsar is switched off. The right column shows the four pulsar spectra, which exhibit the interstellar absorption or stimulated emission of the pulsar signal alone.

of very different solid angles exhibit *similar* statistics. In retrospect, the result is not too surprising, as molecular gas is known to be more clumped than neutral gas.

Our search for OH absorption and stimulated emission in the spectrum of pulsars yielded a bonanza of interesting results in the direction of one source, B1641-45. We detected the first pulsed interstellar maser line, which provides direct evidence for stimulated emission in the ISM. We observed emission or absorption in the pulsar spectra at all four 18-cm OH lines, with conjugate behaviour observed at 1612/1720 MHz. We mapped the OH and HII concentrations along the line of sight to the pulsar, found that they are associated kinematically and probably spatially as well. The optical depths of pulsar spectral lines are much greater than pulsar-*off* lines, demonstrating that the molecular medium is significantly clumped at small scales.

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Regular items

SKA progress report

Progress is being made in many areas of SKA research and development within ATNF. Important milestones have been reached recently in the progress towards a New Technology Demonstrator telescope, and in the area of SKA siting studies. These two areas are highlighted below.

The SKA New Technology Demonstrator (NTD) project

Australian scientists and engineers have been continuing development of SKA technology concepts as funded by the Australian government through the Australian Astronomy Major New Research Facilities Program. After withdrawal, in 2004, of the Luneberg Lens concept as a candidate SKA design, ATNF has been continuing to work on the alternative SKA technology concepts that have been under development in Australia as part of the New Technology Demonstrator project of the MNRF program. The Australian SKA community decided, at the MNRF review point in 2004, that the NTD will be a technology demonstrator for wide field-of-view, low frequency, SKA solutions. The NTD project has now focused on the development of focal-plane array technology in association with parabolic reflectors for the antenna systems. The NTD team is being led by Dr Colin Jacka from the CSIRO ICT Centre and managed by Dr Tony Sweetnam, also from the CSIRO ICT Centre. The project has successfully completed a concept design review and is aiming towards a Critical Design Review point in December 2005. The technology objectives of the NTD are:

- 10 ×10 Focal Plane Array (FPA) operating over the frequency range 800 – 1700 MHz, with one to three parabolic reflector antennas;
- Radio frequency interference (RFI) and spectral line ripple cancellation using FPA (commercial applications are possible);
- RF and IF beam-forming to give extremely wide fields of view;
- Polarisation purity;
- Correlation of large number (at least 20) of independent beams;
- Wide-band operation with low RFI levels; and
- Proof of infrastructure in remote desert environment (power supply, on-site data transport).

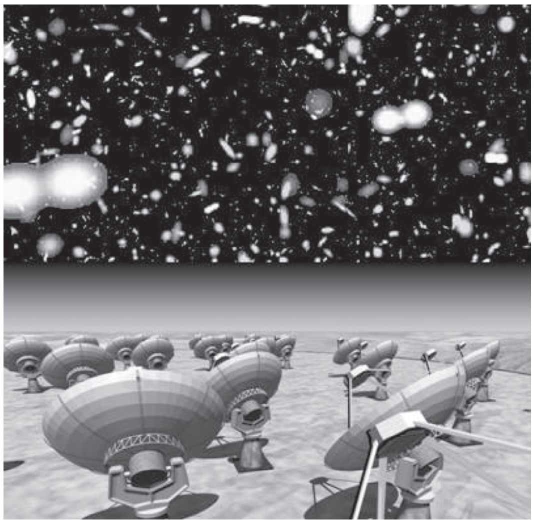

Figure 1: A visualisation of what the SKA could look like if constructed from the technology being considered for the New Technology Demonstrator project. Each parabolic dish is 15 metres in diameter. Image credit: Chris Fluke, Centre for Astrophysics and Supercomputing, Swinburne University of Technology, Australia, and Brian Boyle, CSIRO ATNF.

A plan has also been developed for an extended NTD telescope, which will be possible with additional funding to enable:

- Modular upgrade path. Twenty parabolic reflectors equipped with 10 ×10 FPAs;
- Correlation of a large number of antennas, and 20 independent beams being formed;
- Real-time VLBI using high speed fibre-optic data links with other antennas forming long baselines on the continent of Australia;
- Multiplexed VLBI exploiting wide field-of-view and multiple beams;
- Special purpose signal processors (e.g. for pulsar searches) using phased array beams; and
- Operational and processing software development.

As flagged at the previous AT Users Committee (ATUC) meeting, ATUC will organise an xNTD science workshop in Sydney in early April 2005. Further details will be available via the ATNF website and email before this time. Some of the scientific objectives of the xNTD project are:

- An all-sky HI emission survey to z ~ 0.1;
- A deep survey in HI to z ~ 0.3;
- HI absorption to z ~ 0.7;
- All-sky continuum surveys and monitoring of transient sources;

- Mapping the Galactic HI with high brightness sensitivity;
- Pulsar surveys;
- Multiplexed VLBI on faint sources in deep imaging over wide field-of-view, with phase referenced calibration;
- A large area survey for OH megamasers to z ~ 1; and
- Probe galactic and extra-galactic magnetic fields.

A further purpose of the xNTD is to establish a significant presence at a remote low RFI site, highly suitable for the xNTD and other SKA pathfinder instruments.

Australian SKA siting activities

The Australian SKA Consortium Committee has selected a Western Australian site, centred on Mileura Station in the mid-west region of WA, as Australia's candidate SKA site.

The deadline for responses to the international Request for Proposals for SKA siting is 31 December 2005. Over the next year, information on the central site and the remote sites, as well as information on many other aspects of Australian SKA siting, will be collated and a proposal compiled.

Radio-frequency monitoring program

One requirement of the request for proposals is that site proponents conduct 12 months radio-frequency monitoring on the candidate site. The Australian SKA site bid has reached a significant milestone with the

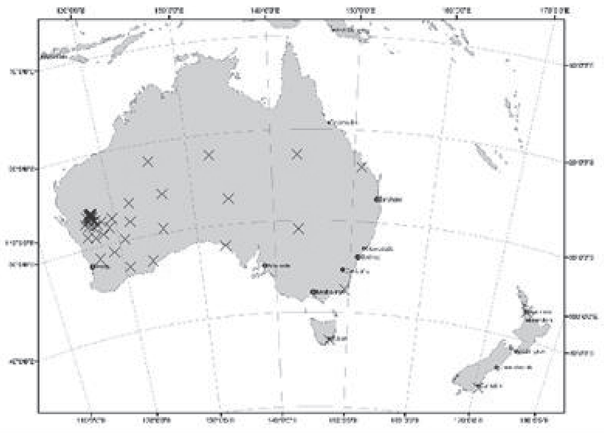

Figure 2: Diagram illustrating a possible configuration of array-stations for an SKA centred at Mileura Station. Each cross represents a cluster of antennas (an array-station) approximately 200 m in diameter. About half of all the array-stations lie within a 5-km diameter central region. There are 100 array-stations in total. Image credit: Steven Tingay, Swinburne University.

Photo credit: Ron Beresford, CSIRO ATNF.

Figure 3: The remotely operating radio-frequency monitoring set-up at Mileura Station

Australia Day deployment of the Radio Frequency Environment test kit at the remote Mileura Station, located 850 kms NW of Perth, WA.

The instrumentation includes a suite of calibrated antennas and low noise front-ends to characterise the potential radio interference levels from 50 MHz to 24 GHz at the prospective SKA core location in accordance with international SKA protocol.

A Rohde & Schwarz spectrum analyser driven by Labview software continually streams data in Microsoft SQL Database to large hard-drives. Particular attention was made to the reduction of self generated RFI and all digital equipment is housed in a screened enclosure.

The system is mobile, solar-powered and was designed and constructed for continuous 24/7 operation over the next year. A weather station has also been installed at the site. Curtin University (Perth) is already actively involved in field support and data reduction.

Radio-quiet Zone (RQZ)

A further requirement of the Request For Proposals is that site proponents indicate the strategy proposed for establishment of a radio-quiet zone for the SKA array-stations, to protect operation of the telescope from increase in man-made radio-frequency emissions. After a Government Forum held at Parliament House in August 2004, negotiations are continuing between ATNF, the Australian Communications Authority, and the Government of Western Australia to develop procedures for the implementation of a radio-quiet zone.

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ATNF outreach

Summer vacation program

For the 2004/2005 summer vacation program the ATNF received almost 200 applications and accepted six students. This was the first time that the ATNF program did not involve other CSIRO Divisions or other Australian institutions. A consequence of the smaller group was that the students quickly got to know each other and formed a strong group. Four of the students were based in Sydney, and two at the Parkes Observatory. The students arrived in early December and spent 10 weeks working on a broad range of research projects, described in the report below. They also spent several days at the Compact Array where 36 hours of observing time was allocated for three group projects. The Narrabri observations were ably supported by Juergen Ott. The program ended with a half-day symposium where the students presented excellent talks on their research and the observatory trip.

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Planet Earth is pretty much home

Scientists, physicists, engineers, computer programmers and a teacher – the 2004/2005 summer vacation students were a mixed bunch of early 20-year-olds with a wide range of backgrounds, skills and aspirations.

We all applied for the summer program for something interesting to do and were certainly not disappointed. However, we had varying aspirations. Nadia wanted to play with a telescope; Joris was looking for an entry into real astronomy after completing his masters in radio astronomy in Sweden; Jamil was keen to network. I believe the Narrabri snake was not a contact Jamil expected or hoped for, but it certainly capped off a memorable week.

Over the course of the summer program I asked my peers "why are you here; what are you doing?" After receiving many blank expressions, I rephrased my philosophical questions of creation and existence and discovered a little bit about the various projects we were working on.

Jamil worked on high speed data transfer from telescopes around the world to a common correlator in CSIRO; apparently "speed is essential in this". From flagging unreliable data to improving image quality Joris came to know UGCA 438, an irregular dwarf galaxy. His intimate knowledge of UGCA 438

Photocredit: Shaun Amy

Figure 1: ATNF 2004/2005 summer vacation students. Back row: Peter Hansen, Nadia Davidson, Jamil Zaman, Joris Verbiest. Front row: Michael Klinkert, Ruchir Gupta.

enabled Joris to calculate the total mass of HI present and examine phenomena such as galactic rotation and its dark matter content. Nadia worked on software development for the virtual observatory project, specifically looking at converting coordinate, time, frequency etc. from one reference frame, or coordinate system, into another. Nadia used the current aips++ service module and produced an interactive web interface. Peter examined the impact that recent surface upgrades to the Parkes radio telescope have had on wind loading. The effect of wind loading on the Parkes radio telescope is vital to the continuing usage of the Parkes research facility. Ruchir focussed on Fourier transforms while characterising pulsar timing noise. I produced school and teacher information packages specifically designed to inform teachers of exactly what is at the Parkes visitors centre. I also created numerous directed learning activities for students visiting the Dish and post-visit classroom material.

The future for us is also diverse. Jamil will complete his studies at Melbourne University and plans to visit "home" in Bangladesh at some stage. Joris enjoyed his summer so much he has chosen to pursue his PhD in Australia despite previous studies in Sweden, Norway and Belgium. Nadia plans to complete honours in particle physics in Melbourne. Peter will find out soon if he is successful in gaining a PhD scholarship with CSIRO and QCAT. Ruchir will complete his studies in Sydney. I have already begun teaching high school Maths and Science in Canberra.

On behalf of the 2004/2005 summer vacation students, I would like to thank everyone at ATNF for the opportunity, new friendships and a stack of memories.

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Parkes Observatory report

Staff

In December 2004 Laurelle Price left the Observatory after five years of sterling service in the Visitors Centre, where she had been one of two part-time staff forming the backbone of the team serving more than 100,000 visitors a year. Greg Ballantyne joined the Visitors Centre as a casual staff member in December.

Tom Lees is on extended sick leave after shoulder surgery in mid-December. The operation was a success, but the recovery will take some weeks and Tom hopes to return to work around mid-March. In the meantime we are pleased to welcome Scott Brady, who is very capably filling Tom's role in the site services group.

We were sad to farewell Jess Lees, our trainee in Administration. Jess performed admirably in all facets of her role during her year with us, and we wish her every success in her future studies. Kayla Strudwick will join the Observatory staff as the new administrative trainee in the second week of February.

This summer the Observatory hosted its first Vacation Scholars. Michael Klinkert worked with John Smith, VC Manager and coordinator (see below) and Peter Hansen worked with Lewis Ball and Mike Kesteven on the wind loading on the telescope (see the report on page 24).

Bushfires

A menacing grass fire broke out in the vicinity of the Observatory on 30 November 2004, creating serious concern and interrupting observing. Fortunately local fire brigades contained the fire that evening, relieving any immediate threat to the Observatory. However the remnants of the fire were rekindled by strong winds during the afternoon of the following day, with the front passing within about one kilometre of the Observatory before racing North and prompting the evacuation of Alectown.

As happens in such circumstances, the flow of information was less than perfect and initial reports by local authorities that the Observatory had been completely destroyed were grossly exaggerated! A number of staff with fire-fighting training patrolled the boundaries of the Observatory and fire breaks were significantly widened. Two other trained staff provided direct assistance to local bush fire-brigades in containing the fire and mopping up.

While no houses were lost and there were no injuries, a number of the Observatory's neighbours suffered significant losses of crops, fences and stock. A full assessment of the Observatory's preparedness for and response to the situation has been completed. The outcome of the assessment was generally positive. Some opportunities for improvement are already being acted upon.

Visitors Centre and Outreach

Over the 2004 calendar year the Visitors Centre hosted approximately 130 000 members of the public. The Visitors Centre enjoyed high visitor numbers over the Christmas, New Year and Parkes Elvis Festival season, with up to 1000 people visiting each day. During this period, a trial of extended opening hours was carried out. Extended hours are likely to continue during school holidays and long weekends.

The original proprietors of the "dish café", Andrea and Michael Carter, sold the business in December after nearly two years of operation. Andrea and Michael conceived the idea of having a cafe at the Observatory, and worked with ATNF and CSIRO staff for around two years to realise their vision. The cafe has proved a most popular addition to the facilities for Observatory visitors. After running the cafe seven-days-a-week, Andrea and Michael will now have more time with their three young children. We thank them for their contributions to the Observatory, and wish them well for the future.

The new proprietors of the cafe are Craig and Rochelle Smith. Craig is a qualified chef and has 20 years experience in the food industry. The menu has changed but the emphasis on great coffee and high quality food at reasonable prices remains.

This summer ATNF had its first Outreach Summer Vacation Scholar, based at Parkes. Michael Klinkert developed materials and activities for schools visiting the observatories. The material is already in use at Parkes and will be further developed for use at Narrabri.

The Observatory's partnership with Swinburne Centre for Astrophysics and Supercomputing continues to be rewarding. Swinburne and ATNF are currently working on a 3D virtual tour of the telescope, an exciting project considering the number of visitors wanting to see inside the telescope. Much of the tour footage will be shot at the beginning of the April 2005 observing term and we expect the show to premiere towards the middle of the year. In January, Swinburne's latest 3D show "After Stars" started screening at the visitors centre. "After Stars" follows a red supergiant that is about to explode and considers whether it will produce a black hole or a pulsar. The show has proved popular, especially since it relates to astronomy conducted at Parkes.

Operations

Telescope operations this year have continued to be largely trouble free, with 1.5% of time lost to equipment faults in the year to date. The single most significant fault was the failure of one of the Wideband Correlator (WBC) samplers in late January; this has now been fixed. The pattern of high winds in the months December – January continues, with 4.8% of time this year to date lost to weather, rather more than the usual annual average.

Receivers

A problem of growing concern has been instabilities in some of the 20-cm multibeam receiver channels. Three channels, beams 11b, 12b and 13b, are now showing some level of short-term instability in gain that are badly compromising pulsar search observations. The problem in channel 13b is also having some impact on HI (GASS) observations. These problems have arisen since re-installation of the refurbished receiver last September, and are thus far confined to the old LNAs. (Owing to resource conflicts with other ATNF engineering projects, only about half of the original LNAs could be replaced with new units during the initial refurbishment). A second-stage refurbishment replacing all old LNAs is tentatively scheduled for early Oct05 Semester.

Backends

The Multibeam correlator samplers have been upgraded to provide 4- and 8-MHz bandwidths for all 13 beams of the multibeam receiver. Previously these bandwidths were available only for the seven inner beams. This project was carried through very ably by Tim Ruckley and Mark Leach. Along the way they found the cause of, and solved, a long-standing niggling problem of low-level “birdies” in the multibeam spectra.

A significant increase in the power and flexibility of the multibeam correlator has been realised by co-locating the system with the Wideband (pulsar) correlator in the upstairs control room. This integration of the two correlators was prompted in the first instance by the advent of a major new project, the Galactic All Sky Survey (GASS). This project is now observing in a configuration with 13 beams × 2048 spectral channels × 2 polarisations (8-MHz bandwidth), which was not possible before the recent changes. Many other “hybrid” correlator modes are now possible. The changes also allow the possibility of providing the multibeam sampler outputs to “3rd party” devices.

The relocation and merging of the two correlators was “fast tracked” for the GASS project, and was made possible by the tireless cogitations and exertions of many ATNF staff over the last two months, particularly Warwick Wilson, Tim Ruckley, Brett Preisig and Barry Turner.

Interference mitigation

The old microwave tower to the East of the 64-m dish, formerly used in the microwave link to Tidbinbilla, has a new lease on life. The original 3-m dish on this tower has been redeployed to receive TV transmissions in the 50-cm band from Mt Ulandra, 200 km to the South. The excellent reception (or perniciously strong reception, depending on your point of view!) has provided a much superior template of these interfering signals, greatly enhancing the efficiency of the proposed active-cancellation schemes. The system uses the feed from the older 50-cm receiver (used prior to the 10/50-cm receiver).

Site changes

New changes are evident daily at the Observers Quarters as work progresses rapidly on the building of a new kitchen wing. The concrete slab was poured in December, framework was erected in early January and work on the new roof line was progressing well at the end of January. The work occasionally causes disruptions for visitors to the Observatory – and for Quarters staff – for which we apologise. However, the end result will be a vastly improved kitchen and upgraded dining area which will improve facilities for all visitors for many years to come.

Work on the major upgrade of the worst section of the six-km road to the site started in November and was scheduled for completion by mid-December. The upgrade is jointly funded by CSIRO and the Parkes Shire Council and the Council is carrying out the work. Rain and a problem with the supply of gravel needed for the significant widening and raising of the road foundation have delayed progress considerably. The foundation of the first 2-km section of the works was nearly ready for sealing at the end of January, and progress on the remainder will follow immediately.

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Compact Array and Mopra report

Narrabri operations and development

During the Australian summer (from November to February), the 3- and 12-mm systems have not been scheduled on the Compact Array. Although there will be no major changes to the 3-mm systems in the 2005 winter season which begins in May, the summer months have provided an opportunity for ATNF staff to improve some issues that were apparent with the millimetre systems during 2004.

One issue that has been rectified is the optics of antenna 1. When the 3-mm system was installed on antenna 1 in October 2004, it became apparent that the gain and beam pattern of antenna 1 was substantially poorer than for the other antennas. Following photogrammetry on antennas 1, 2 and 6, the reasons for this poor performance were clarified. All of the subreflectors on the Compact Array antennas are somewhat under-engineered. They are not naturally rigid and conform to the design shape only to about one millimetre; this is a large error for 3-mm observations. Following holographic measurements, previous adjustments have shaped the main dish surface to counter the subreflector errors. (Holography measures the combined effect of the main dish and subreflector.) However, more recent work on antenna 1 modified the subreflector, so that the subreflector and main surface were no longer a matched pair. Further holographic measurements and main-surface adjustments for this antenna were done in early February 2005. This reduced the rms surface error of the subreflector/main-surface combination from 290 μm to 150 μm. This implies an improvement in the Ruze efficiency factor at 100 GHz from 23% to 67%. Before the start of the millimetre season, alignment of the subreflectors on antennas 1 and 5 will also be performed.

Other development work in progress includes modifying the water vapour radiometers to allow them to be used as opacity metres and developing 16-MHz filters for the second frequency chain.

On the software front, the LINUX observing system is nearing completion. Many of the observing programs (including CAOBS, VIS, CACAL, CAGET and CATAG) now operate under LINUX. Watch this space for the demise of VMS at Narrabri.

A source of radio interference near 1403 MHz, which affected some HI observers, has been located outside CSIRO property. Interim shielding for this has substantially improved the situation. A replacement of the offending gear is pending.

A special trailer that will be used to monitor the radio frequency interference (RFI) environment at Mileura, recently spent a few days at the Observatory undertaking some shakedown tests, and independently assessing the local RFI environment.

Narrabri storms

The Narrabri district has had its share of extreme weather over the summer. During the night of 9 – 10 December, 160 mm of rain fell in the immediate catchment area, resulting in significant flooding. A section of road near the Narrabri township was partially washed away, and a 100-m section of road on the main access route to the Observatory completely disappeared. Neighbours of the Observatory were rescued by helicopter. The worst flood waters disappeared within a few days. By 12 December it was possible to access the town and antenna 6 using a four-wheel drive. The staff and observers present at the observatory at the time took the isolation in their stride, and the telescope operated normally throughout the episode. From the time of the floods until late January, the road damage meant a different route needed to be taken between the Observatory and the town. This route was again closed on 28 – 29 December after a more minor flood. In late January, the main road to the Observatory was re-opened. However this still has flood-damaged sections. We ask all visitors to drive carefully!

Figure 1: Floodwaters eroding away a section of Yarrie Lake road (the main road to the Observatory).

On 20 January the district experienced a severe storm, with 155 km/hour winds. This caused appreciable damage in the town, with many houses unroofed, sheds demolished and most trees losing branches.

Fortunately the Observatory sustained little damage in the storms. Unfortunately some staff members were less lucky. One had 40 cm of water flooding their house, while another had a section of their home blown in and furniture blown away.

Mopra

Developments at Mopra will be a major focus during 2005. In 2004, the antenna control system and parts of the observing system were replaced or enhanced, and a preliminary version of the new digital filterbank backend was installed. During 2005 we aim to replace the SIS 3-mm receiver with an "ATCA-style" MMIC receiver. We also plan to install the 8-GHz multi-line digital filterbank backend, upgrade other parts of the observing system, and enable remote observations from Narrabri.

An essential component of these developments is the MMIC receiver. The unique capability of the filterbank cannot be exploited without this receiver, nor can remote observing be performed. As with the ATCA 3-mm system, a critical component in the receiver development has been the local oscillator system. Some thought was given to whether the SIS local oscillator system could be used with the new receiver. A more detailed analysis showed this was not practical.

For 2005 APRS Mopra will initially be operated with the SIS receiver. The MMIC receiver will be installed later in the semester when it becomes available. Observations that do not require 115-GHz operation or that would benefit most from the multi-line aspect of the digital filterbank will be scheduled later in the winter.

Staff

In November we welcomed Belinda Adamson to the office at Narrabri. Belinda is with us on a one-year contract while Allison Fairfull is on maternity leave. Also in November, we bid farewell to Debbie Rowe-McDonald. Debbie had been with us for about 30 months, working hard to decrease the entropy of the observatory, by tidying up after the rest of us. In her place we welcome Pam Kelly who has quickly learnt the ropes.

After about 20 months at Narrabri, in early February, Stuart Robertson and Eva Boralv left us to return to Europe. Stuart worked hard to raise Mopra to a higher performance level, through long and tireless stints helping observers. Eva, who worked at the Observatory for one day a week, is largely responsible for the fresh appearance of the Narrabri and Mopra web pages. We wish them the best in their new positions in Europe. In Stuart's place, we welcome Jürgen Ott. Jürgen, currently a Bolton Fellow at Marsfield, will be providing Mopra support over the coming year. Although Jürgen's home base will stay at Marsfield, he will be spending extended periods at Narrabri and Mopra over the winter.

Finally we welcome Philip Peitsch. Philip, a student from Swinburne, will be working in the Electronics Group over the coming six months, with his focus being on Mopra remote operation.

Observer feedback

Figures 2, 3 and 4 show Narrabri and Mopra user feedback for the year 2004, obtained from the online feedback forms (see *www.narrabri.atnf.csiro.au/feedback*). The feedback is shown for all Narrabri observations (108 responses), millimetre observations at Narrabri (16 responses), and Mopra observations (7 responses). Feedback is given on a scale of 1 (extremely poor) to 10 (excellent).

The Compact Array feedback results are very similar to those of 2003. The only significant changes were an improved response to millimetre documentation and a poorer response to weather during millimetre observations.

This was the first year that Mopra feedback responses were collected. Comparing the Mopra responses to the equivalent Narrabri ones, three areas show markedly

Figure 2: Narrabri observer feedback for 2004

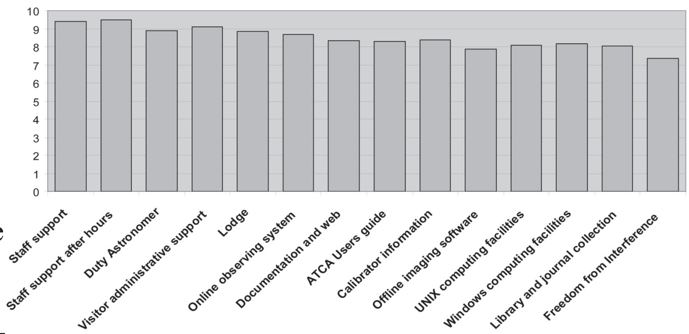


Figure 3: Narrabri millimetre observer feedback for 2004

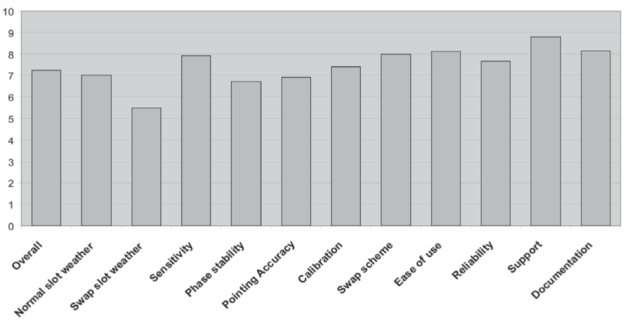
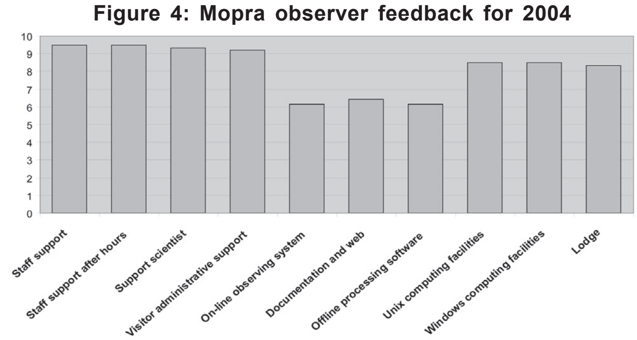


Figure 4: Mopra observer feedback for 2004

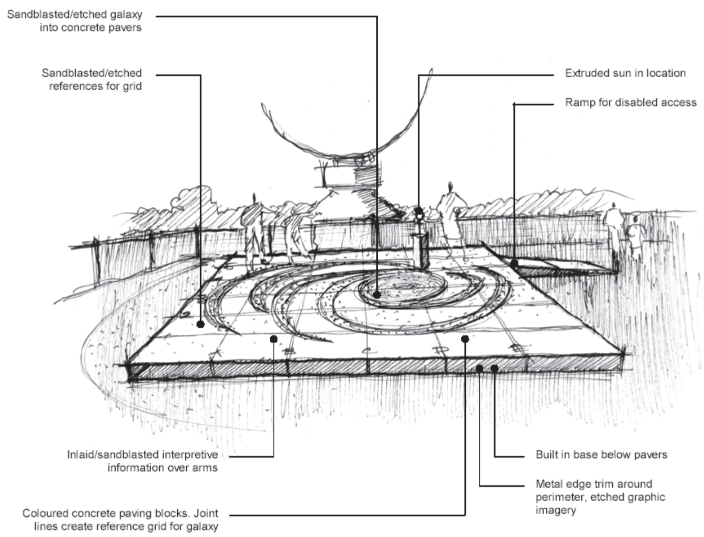


poorer responses: the observing system, documentation/web information and offline processing software. Efforts are being made to improve all three areas of concern.

The fault report system is another way for observers to give useful feedback. Observers are encouraged to use this system: it ensures that faults are responded to appropriately. On average, 1.2 faults reports are received per day. The faults in this system are being addressed at a somewhat higher rate: the number of active fault reports has decreased markedly over the last 30 months.

The user and fault reporting feedback from observers is highly valued and helps the ATNF to identify and address issues promptly.

Figure 5: Indicative sketch of the representation of the Milky Way being constructed as part of the Visitors Centre redevelopment.



Outreach

Development of the garden area around the Narrabri Visitors Centre is proceeding well. A design company has been contracted to develop a variety of displays and exhibits for this area. Work on an observing deck for viewing the antennas is now finished. The centre piece of the redevelopment will be a representation of the Milky Way, located just to the east of the observing deck.

With the recent floods and disruption to the roads, visitor numbers at the Visitor Centre over the Christmas-New Year period were appreciably lower than in previous years. However, these returned to “normal” in January.

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Time assignment information

Application deadlines

Following the change from four-month terms to six-month semesters, there has been some concern in the user community about the time interval between the proposal deadlines and start of a semester. In response to this concern, the application deadlines have been moved by two weeks to shorten this interval. The next deadline will be on 15 June 2005 for observations that will be scheduled between 01 October 2005 and 31 March 2006.

Compact Array

The oversubscription factor for the 2005APRS semester was 2.3. For this semester, the array configurations 6A, 6B, 1.5A, 750A, EW367, H214, H168 and H75 will be scheduled. Observing will be done with the standard 20, 13, 6, 3-cm and 12-mm systems on all six antennas, as well as the 3-mm systems on five antennas (frequency range 83.5 – 106.0 GHz).

The swap method of flexible scheduling will be used for 3-mm projects. It is likely that service mode observing will be granted to some centimetre projects which will be scheduled as swaps for 3-mm observations. During some of the semester, the Compact Array will operate as a split array: the wideband 20-GHz survey (AT20G) will use three antennas, while the remaining three will be available for centimetre observing.

Mopra

In 2005 APRS, the Mopra radio telescope is available for observations at 3-mm wavelength. Mopra will be available with the frequency range 86 – 115 GHz. Observations will also be considered at 20, 13, 6 and 3 cm, and 12-mm wavelengths where it can be demonstrated that Mopra offers a significant advantage over other facilities and/or where a substantial time is required.

The oversubscription factor for the semester was 1.4 during Galactic time. In non-Galactic time (e.g. LST 23:00 to 05:00), a significant amount of time will be unallocated.

With Mopra, the opportunity exists for a substantial fraction of the time to be made available to a small number of large projects, such as surveys. Pilot proposals for future large surveys will also be considered.

Tidbinbilla

The 70-m antenna will be available for the first four months of 2005 APRS. For a period of approximately six months from the end of July 2005, maintenance will be carried out on the azimuth bearing and a new antenna controller will be installed. Because of this, Tidbinbilla proposals submitted for 2005 APRS will remain active for 18 months rather than the usual 12 months. Tidbinbilla remains heavily oversubscribed in Galactic time.

Long Baseline Array

Eight days of LBA observations will be scheduled in 2005 APRS, from 12 – 20 May 2005. The oversubscription factor for the semester is approximately 2. As well as the usual S2 observations, disk-based recorders will be used at all Australian telescopes to provide a near-real-time fringe checking facility.

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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 . This list includes published refereed articles and conference papers, including ATNF data, compiled since the October 2004 newsletter. *Papers which include one or more ATNF authors are indicated by an asterisk.*

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