# ATNF News

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## FEATURES IN THIS ISSUE



CSIRO

## MOPS installation at Mopra and first light

As we enter the 2006 millimetre observing season at the ATNF, the installation of the ATNF's newest and most versatile spectrometer is now complete. The **MOP**ra **S**pectrometer (MOPS) recently completed the final stages of testing on the Mopra millimetre telescope and observations have commenced for 2006, with fascinating results already being produced. ATNF engineers have produced a frequency-agile spectrometer system that will become the envy of millimetre astronomers worldwide. So much so, that the 2006 winter season at Mopra was already over-subscribed well before the fully functioning and operational system was even announced!

### The spectrometer

MOPS is largely a by-product of the development being undertaken for the Compact Array Broadband Backend (CABB) upgrade project. The CABB project, part of the Major National Research Facility (MNRF) program, aims to develop signal processing technologies relevant to the SKA, and to demonstrate them in a new backend for the Compact Array. It is these same signal processing technologies which have been applied to MOPS. Funding for MOPS came from an ARC LIEF (Australian Research Council Linkage Infrastructure Equipment and Facilities) grant to a consortium of universities, led by the University of New South Wales (UNSW), and the ATNF. It was the UNSW astronomers, led by Michael Burton, who originally realised the potential of applying the CABB developments to single dish applications at Mopra, particularly as a wide bandwidth backend for the new Monolithic Millimetre-wave Integrated Circuit (MMIC) based millimetre receiver. It is not only in the signal processing area where MOPS has "borrowed" from other ATNF development projects. The system used to transmit the 8 GHz bandwidth signals over fibre optic cables from the vertex room to the control building was originally developed by Mark Leach for the wideband analogue correlator at the Compact Array. The 4 Gigasample/sec samplers used in MOPS were originally developed by Paul Roberts for the wideband pulsar correlator at Parkes. They use an indium phosphide MMIC 2-bit digitiser designed by Paul as part of a CSIRO Executive Special Project, the same project which saw the development of the indium phosphide MMIC low-noise amplifiers (LNAs) used in the Compact Array and Mopra 12- and 3-mm receivers.

The MOPS signal processing hardware comprises four large circuit boards, one for each 2 GHz quadrant of the total 8 GHz MOPS bandwidth. The boards, which were designed and produced by Dick Ferris and Evan Davis, were developed as prototypes for the CABB system. They are by any measure the most complex Printed Circuit Boards (PCBs) yet produced at the ATNF, each containing seventeen large field programmable gate arrays (FPGAs), which provide the processing power required. Other vital statistics of the boards are: 19 layers, 30,000 pads and 140,000 track segments. The signal


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# Editorial

Welcome to the June 2006 edition of the ATNF News.

This issue is again filled with articles and news items on activities happening at the ATNF. Thank you to all our contributors!

Our cover article, from Warwick Wilson, Erik Muller and Dick Ferris, is about the installation of and first light observations with MOPS, the new frequency-agile, wideband spectrometer for the Mopra telescope. This issue also reports on the first light from the NTD antennas and other NTD, xNTD and SKA news.

As usual we have several science articles. Sarah Maddison and her collaborators contribute new insights into grain growth in proto-planetary disks. There is, once again, exciting news about pulsars, magnetars and RRATs, as presented by Dick Manchester. Compact Array results of another interesting variable radio-emitting source, the newly discovered "Z" source J1701–462, is described by Rob Fender et. al.

In other news, information about the ATNF Spectral Analysis Package (ASAP) is brought to you by Chris Phillips and Malte Marquarding. Dave McConnell introduces to you the new Narrabri Officer-in-Charge, Phil Edwards. The regular Observatory reports include Phil's first contribution for the Compact Array and Mopra.

Dave Jauncey has contributed a news item about the 2006 Grote Reber Gold Medal being awarded to one of the great pioneers of radio astronomy, Bernie Mills. Sadly, we also report the passing of one of the greats of the CSIRO and radio astronomy in general, Jon Ables.

Note that registration is open for the Narrabri Synthesis Imaging School; for details see Ilana Klamer's news item.

We hope you enjoy the newsletter! As always your comments and suggestions are welcome. The web version of this and previous issues can be found at *www.atnf.csiro.au/news/newsletter*.

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# Contents

# SKA and xNTD news

## First light for NTD antenna

On the afternoon of Friday 21 April 2006, the eastern New Technology Demonstrator (NTD) antenna on the Marsfield antenna range saw its "first light", successfully detecting the Orion Nebula.

Over the past few months the antennas have been assembled and a new reflector surface (6 mm x 6 mm mesh) installed. The original gear trains were retained, but new drive and control systems were needed. The eastern antenna now has a simple L-shaped receiver in the primary focus. An uncooled low-noise amplifier (LNA) sends the signal from a single feed to the antenna's pedestal, where it is mixed down to a few tens of megahertz in two stages. Initial tests were performed using the unmodulated beacon of a geo-stationary satellite, Optus B1, with a transmitter positioned on the grass near the antenna. The Orion Nebula was then successfully detected with cross-scans, using approximately 10 MHz of bandwidth (Figure 1).

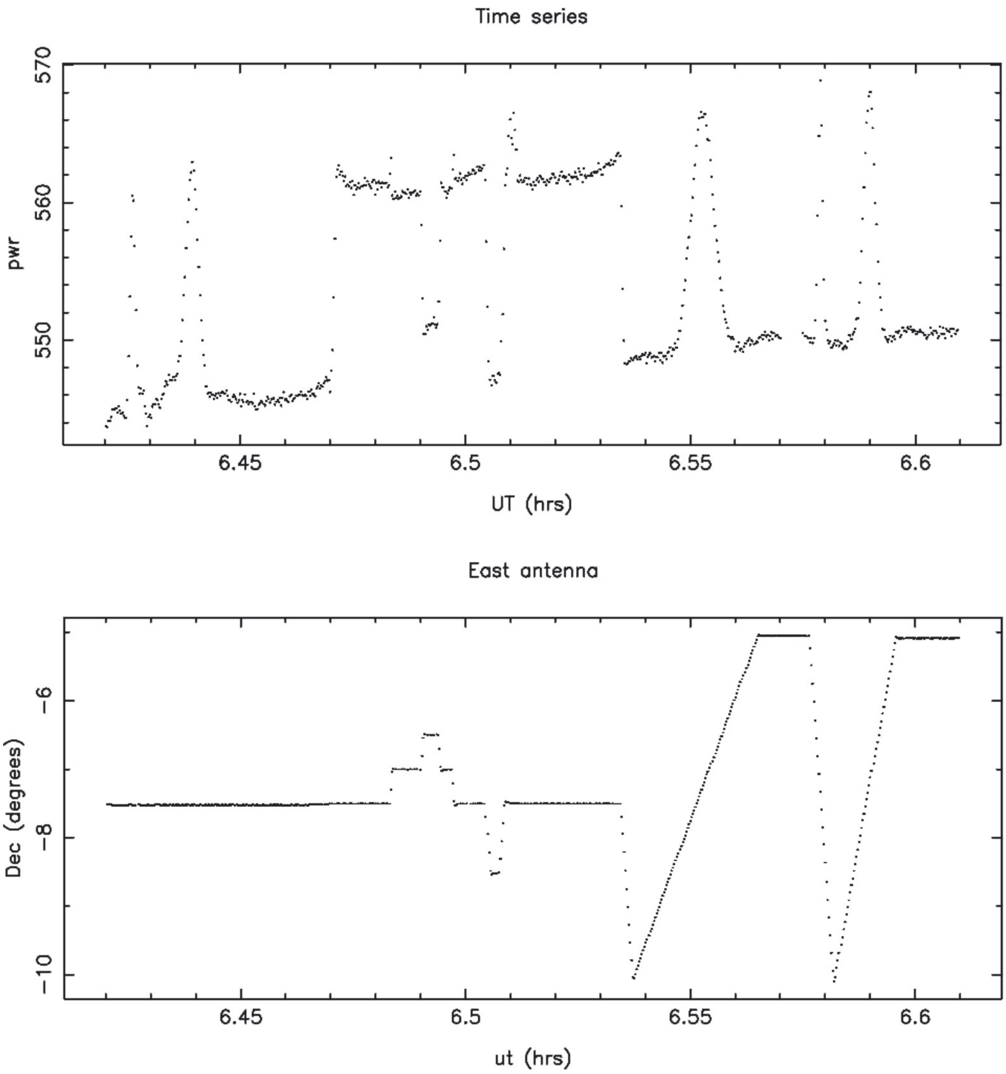


**Figure 1: The upper panel shows the power measured at the conversion chain output as a function of time, and the lower panel shows the antenna offset in declination at the same time. The Orion Nebula is clearly detected during two scans at 6.55 h and 6.59 h.**

Future work includes determining the pointing model, accurately measuring the focus and measuring the far-field reception pattern of the antenna. The procedure will have to be repeated for the western antenna, before experiments can begin with a focal-plane array in one dish and a single-feed receiver in the other.

*Enno Middelberg and Mike Kesteven (Enno.Middelberg@csiro.au)*

### Antenna feeds

Our main tasks now in the NTD project are to further underst and the behaviour of Vivaldi feeds and develop a better design to meet the requirements of the extended New Technology Demonstrator (xNTD) and Square Kilometre Array (SKA) for high dynamic range, frequency coverage and sensitivity to polarisation. We now think that the needs of the xNTD could be better met using a feed based on a periodically loaded linear connected array. This approach would need the design of the LNA to be closely integrated with the feed design. Within the NTD project, we will develop a 5 x 5-element prototype tile that will be further developed for the xNTD.

We recently obtained our first fringes from the two-element interferometer at Marsfield. However, we have not yet mounted the THEA tile (see ATNF News, February 2006) on the East antenna, because lab testing showed that interference from the SBS analogue TV signal at 527 MHz — greater than expected — would create intermodulation problems in our passband above 1 GHz. As a result, we have had to modify the front-end circuits of the THEA by including filters and replacing a buffer amplifier. We now expect to install the THEA tile in July. Meanwhile, investigations of other feed and LNA designs, led by John O'Sullivan, are progressing well.

### Project management

CSIRO is moving to organise and fund its research by "theme", and from 1 July 2006 all the NTD and xNTD projects will be part of a new theme in the ATNF known as "xNTD and SKA Phase 1". The xNTD has been divided into eight projects:

- xNTD System Design, Integration and Infrastructure;
- NTD;
- xNTD Antennas and Control;
- xNTD Smart Feeds;
- xNTD Digital Systems;
- xNTD Receivers;
- xNTD Computing; and
- xNTD Signalling and Data Transport.

The Australian SKA Project Office (ASPO) project will also be incorporated into the theme.

Draft plans for this structure have been submitted to the ATNF Project Review Board (PRB) for approval, and will be finalised and discussed in detail with the PRB in mid-June.

The new theme requires some new positions: a full-time Theme Leader, a second Project Manager, four software engineers, and three engineers for the digital, receiver and data transmission projects. We have begun recruiting.

The xNTD Project Scientist, Simon Johnston, has written a discussion paper on "Science with the xNTD". This can be found at *www.atnf.csiro.au/projects/ska/newdocs/xntd_science31.pdf*, and we invite comments on it.

The xNTD team has been working with Michelle Storey in developing the National Collaborative Research Infrastructure Strategy (NCRIS) Radio Astronomy Investment Plan. The project plan for xNTD has been developed with the NCRIS funding in mind; strategies have been developed to deal with various possible levels of NCRIS funding.

The Low Frequency Demonstrator (LFD) has received funding from the National Science Foundation (NSF), and in the week starting 5 June some members of the xNTD team attended a meeting in San Diego to discuss the instrument's future development. Discussions included how the xNTD and LFD can best benefit and share the infrastructure needed at Mileura, and possible options for use of NCRIS funding.

The xNTD project plans cover the commissioning of the instrument and its early science. Ray Norris has been leading some preliminary discussions on this. In developing plans for commissioning we will draw on experience gained in commissioning other instruments, such as the Compact Array.

Over the past few months we have had considerable interaction with the South African and Canadian SKA teams. Tim Cornwell visited South Africa and has identified common work packages in the software development of the xNTD with the South African KAT project. Three members of the Canadian SKA team spent a week here in May, during which we identified a number of areas in which our two teams could collaborate.

*Colin Jacka*
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## Radio frequency interference at Mileura

In March the ATNF completed an analysis of the data gathered on the radio-frequency environment at Mileura over the previous 12 months. On 10 March

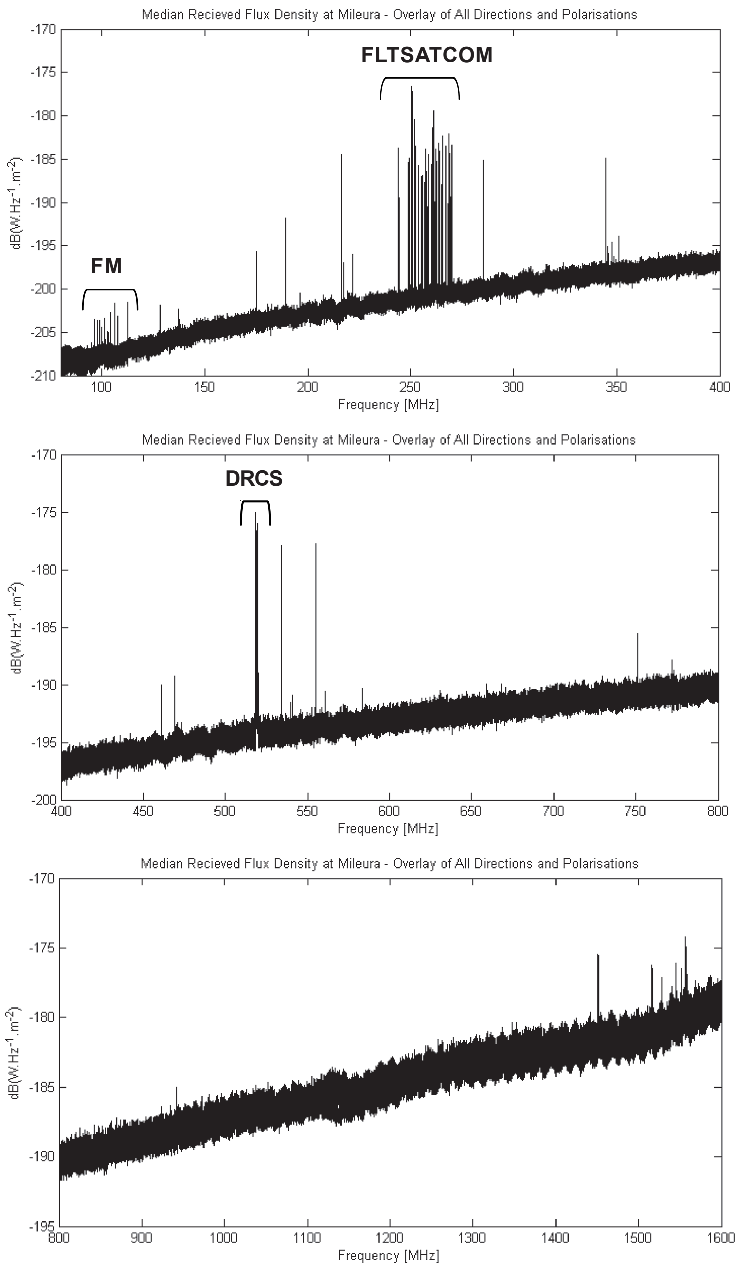


**Figure 2: Median received flux density at Mileura Station. The three plots above show an overlay of all directions and polarisations. The only bands with significant occupancy are the US Navy's Fleet Satellite Communications (FLTSATCOM) bands and the Digital Radio Concentrator System (DRCS) network, providing communication to local homesteads. The FM band is also labelled, although the spectrum occupancy in each 20 MHz band is indistinguishable from the system noise.**

this was presented to the International SKA Planning Office (ISPO), in the form of a 131-page report (plus several hundred pages of appendices). The report included a characterisation of “typical” remote array stations located near Meekatharra and Moora (nearer to Perth). The remote-station measurements were conducted in January/February this year, coincident with the onslaught of several cyclones on the WA NW coast. Locals have credited us with breaking the drought!

Much of the data related to the 50 MHz to 3 GHz region of the spectrum, but smaller datasets were used to characterise the 3 – 26 GHz spectrum.

The results show that spectral occupancy is extremely low, even below 1.6 GHz, which is, internationally, the most crowded; however, the globally ubiquitous US Navy Satellite communications were always present in the 240 to 270 MHz VHF band. Some interesting propagation effects were noted below 1 GHz, such as ionospheric “sporadic E” and tropospheric ducting phenomena. Some sporadic E was from as far away as Queensland. Fortunately such events were only apparent for an hour or so in a week or longer.

The study was partially funded by the Government of Western Australia, under the Major National Research Facilities program.

The Australian Communications and Media Authority (ACMA) has been developing a regulatory framework for a radio-quiet zone (RQZ) to help maintain the radio-quietness of the Mileura site. The ACMA is developing coordination procedures to achieve the best possible result for radio astronomy, without unnecessarily denying radio communication services to the local community. To achieve this balance, it plans to define an inner zone, where licensing of radio communications is tightly restricted, and an outer zone, where radio communications are coordinated in such a way as to minimise interference to radio astronomy.

The ACMA has introduced a spectrum embargo for the area around the proposed SKA core site. This embargo (Embargo 41) applies to new radio communications licences within 150 km of the site for frequencies from 100 to 230 MHz, and within 100 km of the site for frequencies from 230 MHz to 25.25 GHz. It applies to licensed, coordinated terrestrial stations, and satellite ground stations. The embargo is expected to be an interim, short-term solution until detailed coordination procedures are introduced.

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# A new neutron star relativistic jet source in the Galaxy

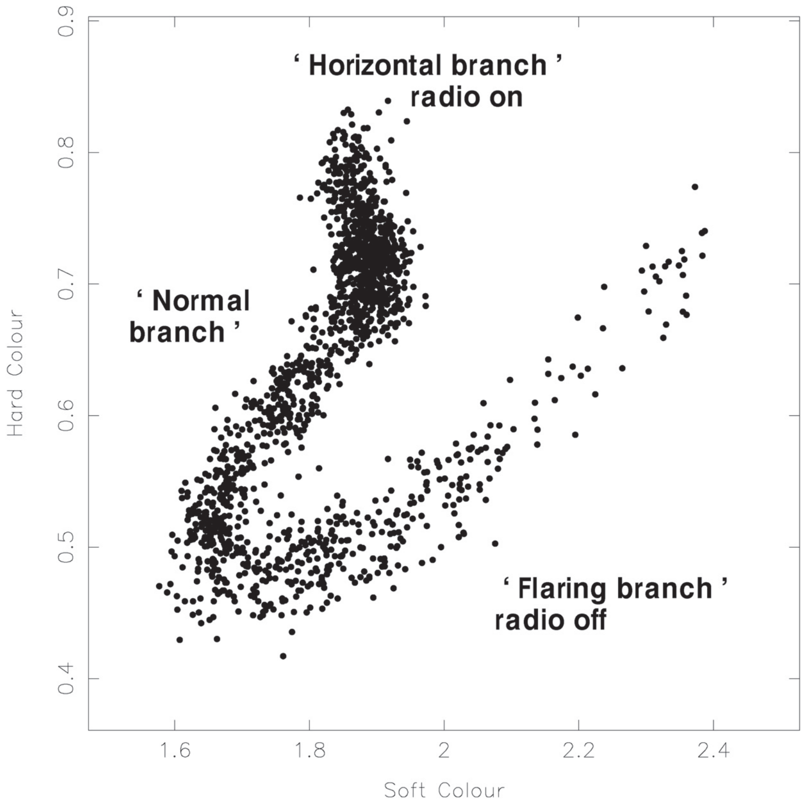


**Figure 1: X-ray colour-colour diagram for the newly-discovered source XTE J1701–462, displaying the three branches characteristic of a “Z source”. Each branch corresponds to a different configuration of the accretion flow in the X-ray binary, and we have found a strong relation between the radio emission and accretion branch. During the radio “on” phases it is likely that this source — which harbours a neutron star, not a black hole — is producing a transient, relativistic radio jet.**

The relation between accretion and outflow is a key topic in modern high energy astrophysics and offers us a unique opportunity to understand the physics of distant, supermassive black holes in active galactic nuclei (AGN) by studying nearby, rapidly varying objects such as X-ray binaries. Much of the focus in recent years has been on black holes; however, neutron star X-ray binaries represent an extremely valuable “control sample” of objects which also produce relativistic jets without requiring an event horizon, ergosphere etc.

The brightest set of neutron star X-ray binaries are the so-called “Z sources”, of which there are currently six or seven identified, all of which have been known since the early days of X-ray astronomy in the 1960s and 1970s. They are all accreting at, or close to, the Eddington limit, and their integrated, steady X-ray emission contributes a significant fraction of the X-ray luminosity of the entire galaxy. Furthermore, they are all radio sources and in two cases, Sco X-1 and Cir X-1, the radio emission has been resolved into relativistic jets.

In January 2006, for the first time, a new, transient, Z source was discovered: XTE J1701–462 was rapidly identified as a member of this exclusive class by its characteristic X-ray timing behaviour (Homan et al. 2006). Following a Director’s time request to the ATNF, we observed this source 15 times with the Compact Array between 22 January and 20 March 2006. During this period the X-ray emission properties varied in the pattern characteristic of a Z source (see Figure 1; hence the name), moving along three distinct spectral branches. Over this period the radio source was also observed to switch “on” and “off”, in a characteristic relation to the X-ray emission (Figure 1). This strongly indicates that XTE J1701–462 is following the same pattern of disc vs jet coupling as the other Z sources, alternating between phases of relativistic jet production and phases of “jet-less” accretion. The most variable of the previously-known Z sources is Circinus X-1, which has been discovered with the Compact Array to harbour the most relativistic jets in the Galaxy (Fender et al. 2004), which power a parsec-scale radio nebula (Stewart et al. 1993). It is not clear how XTE J1701–462 will evolve in the future, but we do know that using the Compact Array together with X-ray observatories we have observed the activation of a powerful new jet source within our Galaxy.

**References**

Fender R., et al. 2004, Nature, 427, 222
Homan J., et al. 2006, Astronomer’s Telegram 725
Stewart R., et al. 1993, MNRAS, 261, 593

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# ASAP – ATNF Spectral Analysis Package

The **A**TNF **S**pectral **A**nalysis **P**ackage is a new software package that has been developed within the ATNF, to reduce single-dish, single-pointing spectral line observations. ASAP is now used for single-dish data from ATNF instruments and should be able to read data from any telescope if the data can be written in the “sdfits” format.

ASAP has been developed in c++ using a python front-end for the user interface. The c++ code makes extensive used of the casa libraries (the package formerly known as aips++).

Standard spectral line calibration and analysis is supported (baseline subtraction, smoothing, statistics, Gaussian fitting, time averaging etc.) as well as a number of advanced functions such as to automatically pair reference and source spectra to form quotient spectra, automatically fit a low order polynomial to line free channels in a spectrum, correct for Doppler shift between scans when averaging and use of frequency switching. Polarimetry support suitable for observing with linear feeds at Parkes is available; this includes various calibration corrections and conversion to Stokes or circular polarisations.

ASAP v2 has recently been released. The main change was a major re-design to support varying numbers of spectral channels per intermediate frequency (IF) or per beam. In particular, ASAP will be used for data from the new wideband MOPS spectrometer at Mopra, as it can process many simultaneous IFs and beams in parallel. For “well behaved” data it is possible to load, calibrate and baseline subtract a multi-beam, multi-IF data set with a small number of commands. Flexible data selection is included to select based on a variety of values (beam, IF, polarisation, source name etc). Power users can also select data on properties such as the system temperature.

Currently only binary versions are available for Debian Linux and OSX. A binary version for Fedora Linux should be available shortly. Other flavours of Linux may work with these binaries — contact the development team for help. ASAP is easy to compile from source, however it depends on having a full version of the casa development libraries installed. The team is also trying to simplify the process of obtaining only the relevant casa libraries.

For more information see *www.atnf.csiro.au/computing/software/asap*.

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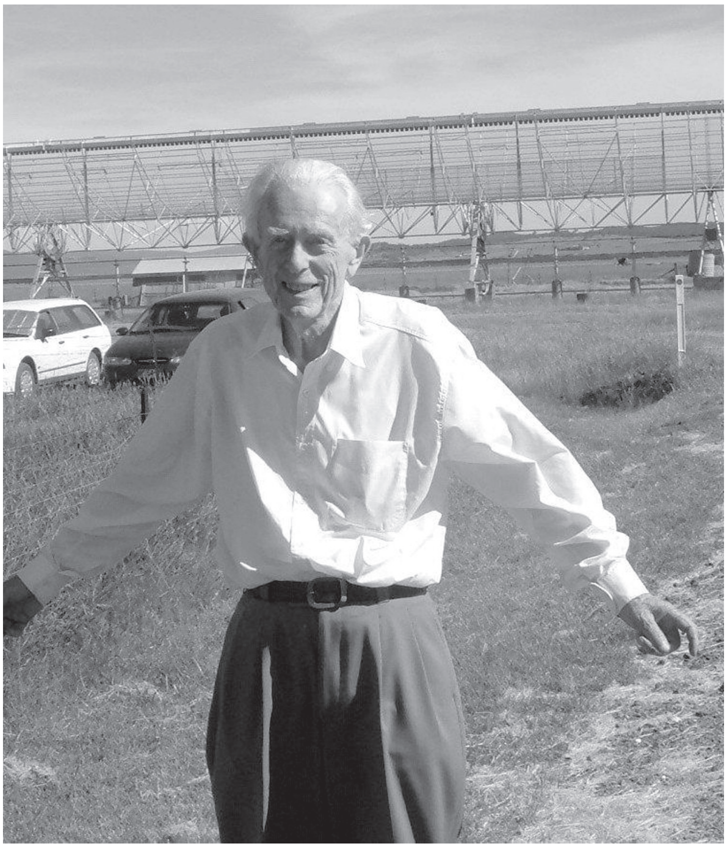
# 2006 Grote Reber Gold Medal awarded to Bernard Yarnton Mills, Professor emeritus at Sydney University

The 2006 Grote Reber Gold Medal will be awarded to Professor B. Y. Mills, one of the early pioneers of radio astronomy. Professor Mills is being honoured for his innovative contributions to the development of radio telescopes and for his pioneering investigations of the radio sky which led to the first estimates of the radio galaxy luminosity function and helped to define their spatial distribution. The medal will be presented at a special ceremony on 17 August, during the IAU General Assembly in Prague, Czech Republic.



**Professor Bernie Mills (Photo courtesy of Crys Mills).**

Professor Mills' pioneering contributions to radio astronomy include the development of the cross-type telescope, subsequently known as the "Mills Cross", at Fleurs, west of Sydney, in 1953. With this instrument he and his colleagues at CSIRO Radiophysics undertook the first detailed radio survey of the southern sky, which had a major impact in establishing Australia as a leader in the then new science of radio astronomy. This first cross spawned copies in Australia, in the US, and in Italy.

After moving to Sydney University in 1960, Mills undertook the construction of the 408 MHz one-mile Molonglo Cross. As well as surveying the radio sky, this telescope proved to be one of the most successful pulsar discovery telescopes. Since then the telescope has been upgraded to operate as a synthesis radio telescope at 843 MHz and has been most successful in sensitively surveying the southern sky, the Magellanic Clouds and the southern Galactic plane.

Bernard Mills, after his retirement in 1985, continues to contemplate fundamental issues of astrophysics.

The Reber Medal was established by the Trustees of the Grote Reber Foundation to honour the achievements of Grote Reber and is administered by the Queen Victoria Museum in Launceston, Tasmania in cooperation with National Radio Astronomy Observatory (NRAO), the University of Tasmania, and the CSIRO Australia Telescope National Facility. Nominations for the 2007 Medal may be sent to Martin George, Queen Victoria Museum, Wellington St, Launceston, Tasmania 7250, Australia or by e-mail to: *martin@gvmag.tas.gov.au* to be received no later than 15 November 2006.

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## New Narrabri Officer-in-Charge

We are pleased to announce that Phil Edwards has joined the ATNF as the Officer-in-Charge of the Narrabri Observatory. Phil holds a PhD from the University of Adelaide in high energy astrophysics and comes to us from Japan, where he has been Assistant Professor at the Institute of Space and Astronautical Science (ISAS). Phil has extensive experience in radio astronomy techniques, particularly in VLBI. While he was with ISAS he worked the VLBI Space Observatory Programme (VSOP), playing a major role in coordination of the mission as well as to conduct his own research.

Phil has moved to Narrabri with his wife Leanne and young children Jack and Harry. We welcome them all.

*Dave McConnell*
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**Dr Phil Edwards**

## Worth the wait ... registration opens for the Synthesis Imaging School

We are pleased to announce that registration has opened for the 7th ATNF Synthesis Imaging School, being held at the Narrabri Observatory (the home of the Compact Array) on 18 – 22 September 2006. As always, this school will be jam-packed with interesting lectures given by a range of excellent local, national and international speakers, covering a wide range of topics central to the synthesis imaging theme. In addition, there will be practical observing sessions, data analysis tutorials and site tours taking in the correlator room and an antenna receiver cabin. As with the previous schools, the only prerequisite is an enthusiasm for radio astronomy and interferometry — no prior experience is required. Accordingly, there will be many opportunities to interact with the speakers at the school, during devoted Q&A sessions as well as at the more informal social gatherings. More information on the program content and the confirmed speakers can be found on our website, directly accessible from a link on the ATNF homepage.

There are several changes to the 2006 school in comparison with previous years. For the first time participants are being encouraged to present a poster at the school describing their research. A prize will be awarded for the best poster. Another change is the venue: this year we are going to use the on-site Visitors Centre, as compared with the "breezeway" (aka table tennis room) which has hosted all previous schools. In addition, due to the distinct possibility of torrential rain (those who recall the 1999 school will know), the traditional pizza night has been replaced with a function at the Narrabri Golf Club in town.

The registration fee for the school is set at $200 for students and $250 for everyone else. This fee covers all lunches, as well as two dinner events (see below). Registration opened on 29 May and will remain open until 28 July, or until the number of registrations reaches 70 — whichever occurs first. Financial assistance will be offered to students who are not fully supported by their home institutions. Requests for this assistance should be made on the registration form.

Owing to the 12-month postponement of this biennial event, we anticipate a larger than usual number of interested participants. We therefore encourage you to register early, because there is limited capacity at the Visitors Centre (70 people) and we don't want you to miss out!

*See you all in Narrabri!*
*Ilana Klamer, on behalf of the SOC and LOC*
*(Ilana.Klamer@csiro.au)*

# Jon Ables 1937 – 2006

Photo: © CSIRo

Jon Ables

It is very sad to hear of the passing of Jon Ables. Jon was well-known and highly respected by various sections of the scientific community, encompassing scientists and engineers from all age groups.

Perusal of Jon's publications provides some idea of the scope of his involvement across many fields, but it does not really reveal the significance of Jon's original thinking in the conception of these ideas. But those fortunate enough to have worked with Jon fully understand this.

In the radio astronomy area, Jon was widely known for his proposal for using Maximum Entropy Methods (MEM). His publication in 1974, titled "Maximum Entropy Spectral Analysis" has been extensively referenced in the literature of radio astronomy, medical imaging, crystallography, radar, various mathematical journals and many other application areas that rely on image coding, image reconstruction and image restoration. This paper has had a profound effect on the careers of many scientists.

Jon was an outstanding astronomer, especially in the early days of pulsar research. He proposed unique instrumentation methods, detailed designs and led some major discovery projects. This has led to the discovery of the first pulsar in another galaxy, theoretical explanation of pulsar broadening due to interstellar scattering, and theory of coherent diffraction in pulsar emission.

Jon was the inventor of many things. He was well-known for his design of the A4 digital audio processor chip, the development of the concept for a systolic array very-large-scale integrated (VLSI) cross-correlator chip that has served the ATNF extremely well, his Unified Clock Principle that influenced the design of the Compact Array, the Encoded Mask X-Ray Camera, the concept of the "distributed clock" now used in all ATNF telescopes and correlators and adopted by other observatories, and numerous other schemes in recent years related to medical diagnosis and monitoring. There are very few scientists that have the breadth of expertise that characterised Jon Ables. Jon had a sound background in science, a remarkable intellect and a single-mindedness that let him follow through on his hunches.

Jon Ables was the Director of the Parkes radio telescope from 1981 to 1989, and during that time led the support of the reception of data and images from the NASA Voyager 2 fly-by of the planets Uranus and Neptune, and the ESA Giotto space probe to Halley's comet. This period involved much negotiation with these two space agencies, and Jon's technical expertise was greatly appreciated by them. Under Jon's leadership, Parkes was extensively upgraded, incorporating many of his own concepts and design ideas. NASA and ESA felt assured that Parkes was under strong technical and managerial leadership and were confident that CSIRO would be a reliable partner for their important space missions.

Everyone looked forward to Jon's presentations. There would always be something new revealed, and in such an entertaining manner. We also looked forward to Jon's presence at social functions. He told entrancing stories, all part of his experiences, and his impeccable memory allowed him to tell every joke that he had ever heard. As a mentor for the younger staff, Jon was exceptional. We have all benefited greatly from Jon's skills. For many years, the offices and laboratories of the Signal & Imaging Technology Program were deliberately laid out so that Jon's favourite area was central. This was the meeting place for all to learn and all to have fun. It was a huge success; the pivot was Jon Ables.

### Perspectives from Jon's most recent team (microwave cardiac sensing)

Jon was what some may refer to as an "old school" scientist, a scientist in the classical sense from basic theory, to generating a hypothesis and testing that hypothesis. His method of generating ideas seemed almost chaotic, and it may have appeared that he wasn't going towards any end goals, but those who worked with him know that he was the driving force behind the science of every project he worked on. Although it was sometimes difficult to see exactly what was happening, when his team had achieved its goal, you realised that he knew exactly what he was heading towards. Jon had a strong basis in the fundamentals of his physics, he had brilliant practical and engineering skills so that he could put the fundamentals into the real world, and as he put it, he had the sales skills that he had picked up in the Ozarks. He was one of the most well-rounded scientists in this or any other organisation. Many saw him as a mentor, he had the brilliant ability of being able to explain a concept to the layperson, yet at the same time, he was in circles that included Nobel laureates.

This breadth-of-skill set was what drew the young(er!) scientists to him. Jon has pretty much enhanced the career of everyone who has worked with him, up to this very day. Jon was also by no means a narrow man; he had many interests in music, talking often about his taste in blues and jazz as well as his love of the composer Philip Glass amongst others. Jon was also quite a handy cook as many who have tasted his food will tell you. He would often blend the tastes from his native Oklahoma with his love of Indian and Mauritian cuisines, and he loved eating Sushi. His plan after CSIRO (Jon had many plans!) was to drive a camper van around the outback, and he was in the process of converting his ute into a camper.

Ironically, Jon's passing away comes at a time when the CSIRO is celebrating its 80th birthday, and the radio astronomy group its 60th, which means that Jon was there for a good half of that time. His love of the organisation and CSIRO was such that early in his career he had turned down job offers from the NRAO, amongst others.

Jon's passion for radio astronomy meant he lost all sense of 9 to 5, and would turn up at the lab at all hours and most weekends.

In recent years, many of the younger scientists working around Jon referred to him as the oracle — any problem you had, he could usually come up with a novel way of solving it, or give you some insight to set you on the right path.

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# Articles

## Pulsars, magnetars and RRATs

Pulsars are fascinating objects which impact on many areas of astronomy and physics. Observed as celestial sources where the emission is in the form of a highly periodic train of pulses, they are generally believed to be rotating and highly magnetised neutron stars. This combination of strong magnetic fields and rapid rotation generates huge voltages across the star and in its magnetosphere, leading to the formation of ultra-relativistic beams of electrons and positrons and ultimately to beamed radiation at wavelengths that range from low radio frequencies to high-energy gamma rays. These beams sweep across the sky as the star rotates so an observer who happens to lie in the path of a beam sees one pulse per revolution of the star. Over 1,600 pulsars are now known and their pulse periods cover the range between 1.4 milliseconds and 12 seconds (see the ATNF Pulsar Catalogue at *www.atnf.csiro.au/research/pulsar/psrcat*).

Pulsars come in several different flavours, distinguished by different period ranges and/or pulse emission properties. Radio pulsars are divided into two main groups, millisecond pulsars and 'normal' pulsars. Most millisecond pulsars have periods in the range 1 – 30 ms as their name suggests, but a principal distinguishing characteristic is a very slow spin-down rate, indicating a weak external magnetic field. It is believed that both the rapid spin and the low magnetic field for these pulsars result from accretion of mass and angular momentum from a binary companion star in an earlier accretion phase. The system may be visible as an X-ray pulsar during this phase. The vast majority of pulsars are normal (again as the name suggests!) with periods mostly in the range 30 ms to 8 s and large period derivatives, indicating ages of a few million years or less and relatively strong magnetic fields, typically of order $10^{12}$ Gauss. A separate class of pulsars known as Anomalous X-ray Pulsars (AXPs) or Soft Gamma-ray Repeaters (SGRs) are generally detected at X-ray or low $\gamma$-ray energies and have long periods in the range 5 – 12 s. These pulsars have a very rapid spin-down rate, indicating surface magnetic fields as large as $10^{15}$ Gauss. Despite the rapid spin-down of these "magnetars", the loss of rotational kinetic energy is insufficient to power the observed X-ray and $\gamma$-ray emission. It is believed that decay of the super-strong magnetic fields is the main energy source powering the emission in these sources.

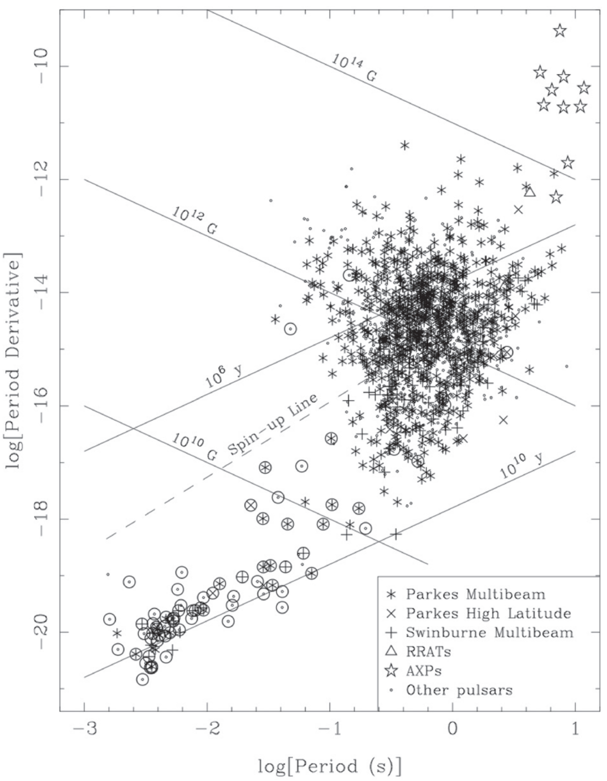


**Figure 1: Pulsar period derivative versus pulsar period for all known Galactic disk pulsars. Pulsars discovered at Parkes in major surveys using the 20-cm multibeam receiver, RRATs and AXPs are indicated. Binary pulsars are indicated by a circle around the symbol. Lines of constant characteristic age, $\tau_c = P/(2\dot{P})$, surface dipole magnetic field, $B_s \sim (P\dot{P})^{1/2}$, and the spin-up line, which represents the minimum period that a pulsar can attain through accretion of mass from a companion star, are shown.**

These different groups of pulsars are easily distinguished on a plot of pulsar period derivative (or spin-down rate) versus pulsar period (Figure 1). Millisecond pulsars are grouped in the lower left of the diagram, whereas AXPs are at the top right. About 75% of all millisecond pulsars are members of a binary system, that is, in orbit around another star, whereas only a few per cent of normal pulsars are binary. Young pulsars, similar to those associated with the

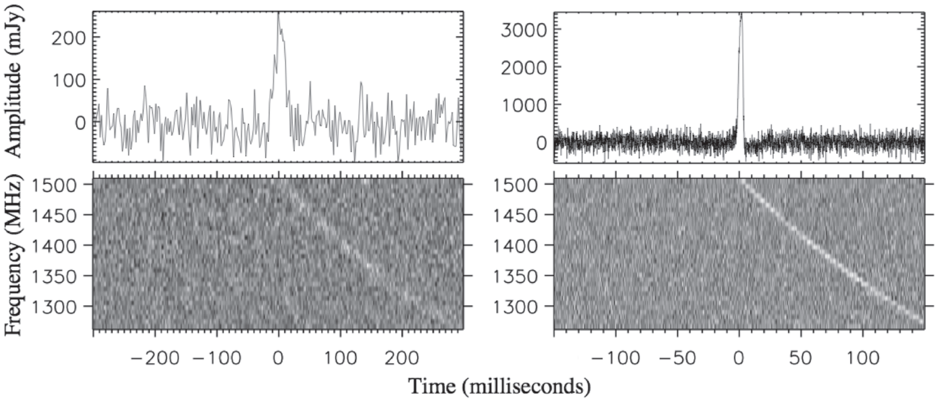


**Figure 2: Isolated pulses from two RRATs, PSR J1443–60 and PSR J1819–1458. The lower part of each plot shows the dispersion of the pulse as a function of frequency and the upper plot shows the de-dispersed pulse profile. (Image credit: M McLaughlin)**

Crab and Vela supernova remnants, live in the upper left of the diagram and evolve to the right, possibly along lines of constant magnetic field, joining the vast bulk of pulsars in the "pulsar island" centred around period 0.6 s and period derivative $10^{-15}$.

The Parkes multibeam pulsar surveys have been remarkably successful, finding over 750 (nearly half) of the known pulsars. These discoveries have not only provided a superb database for various studies including pulsar and binary evolution, the Galactic distribution of pulsars and interstellar magnetic fields, they have also revealed many individual objects which are of special interest. Standing out among these is the first-known double pulsar, PSR J0737–3039A/B, a remarkable system which is providing the most stringent tests yet of relativistic theories of gravitation and giving new insights into pulsar magnetospheric physics (e.g., McLaughlin et al. 2005, Kramer et al. 2006). But there have been many others, for example, PSR J1119–6127, just 1700 years old and lying in the centre of the supernova remnant G292.2–0.5 (Crawford et al. 2001), and PSR J1740–3052, a binary pulsar in an eccentric 230-day orbit with a companion star which has a mass of at least 11 times that of the Sun (Stairs et al. 2001) and which just might be a black hole.

The Parkes multibeam survey has been particularly successful at finding relatively young but long-period pulsars. As Figure 1 shows, ten or so pulsars like this, lying across the top of the distribution of normal pulsars, have been found where none were previously known. The large period derivatives of these pulsars imply that they have very strong magnetic fields. In fact, some lie in the part of the $P\dot{P}$ diagram occupied by AXPs. Until recently, there was no direct connection between these high-B radio pulsars and the AXPs other than their similar location on the $P\dot{P}$ diagram. Searches for X-ray emission from the long-period radio pulsars have revealed X-ray emission from some pulsars (e.g., Kaspi & McLaughlin 2005), but the emission is weak and has a thermal spectrum, quite unlike that from magnetars and probably originating directly from the hot neutron-star surface. Conversely, most searches for radio emission from magnetars have been unsuccessful. Pulsed emission at low frequencies, ~100 MHz, from several magnetars has been claimed by Russian astronomers (e.g., Malofeev et al. 2005), but other observers have failed to reproduce these results (e.g., Lorimer & Xilouris 2000).

This situation has changed dramatically with the recent discovery of strong pulsed radio emission from the magnetar PSR J1809–1943 (XTE 1810–197) by Camilo et al. (2006). Pulses were first detected using the 20-cm multibeam receiver on the Parkes radio telescope, but were subsequently detected at much higher frequencies using both Parkes and the Green Bank Telescope (GBT). Individual pulses can be seen at frequencies as high as 42 GHz, making this pulsar one of the strongest known at high radio frequencies and showing that it has an essentially flat radio spectrum. Interestingly, this pulsar was not detected in the Parkes multibeam survey although it was in the survey area, placing a limit on the flux density in 1997 – 1998 of less than 10% of the present value. This clearly shows that the pulsed emission is highly variable. The radio brightening of PSR J1809–1943 may have occurred in 2003 when there was a large increase in the X-ray emission. It is possible that similar variability may account for the non-confirmation of the Russian detections of other magnetars.

The Parkes multibeam pulsar survey also turned up another class of transient source, the so-called RRATs, an acronym standing for **R**otating **RA**dio **T**ransients. Reanalysis of the survey data with a detection algorithm sensitive to single dispersed pulses has revealed a total of eleven such sources (McLaughlin et al. 2006). RRATs are characterised by the emission of isolated pulses at intervals ranging from a few minutes to a few hours. Radio searches are plagued by various types of interference including impulsive bursts from electrical equipment. However, these interference bursts are undispersed and so can be separated from distant astrophysical sources by the dispersion that the signal suffers in propagating through the interstellar medium (Figure 2). Repeated detection of pulses from the same direction in the sky with the same dispersion confirms a real astrophysical source.

An analysis of the arrival times of the pulses for each source showed that pairs of pulses were separated by intervals which were always a multiple of a given shorter interval. The smallest of these common factors ranged between 0.42 and 6.79 s for the different sources and is identified as the rotation period of an underlying neutron star. This identification was confirmed using standard pulsar-timing techniques which showed that, for at least three of the sources, the periods increase slowly with time in exactly the same way as normal pulsar periods. In one of these sources, which has a period of 4.26 s, the implied surface dipole magnetic field is $5 \times 10^{13}$ G, placing it right up with the high-B pulsars and not too far from the AXPs on the $P\dot{P}$ diagram (Figure 1). RRATs have much longer periods on average than normal pulsars, again suggesting a connection with the high-B pulsars. However, as with the AXPs, the emission properties are very different. In no case have two consecutive pulses been observed from a RRAT, showing that the emission is strong for a time less than the rotation period of the neutron star. The emission must be beamed as for a normal pulsar, otherwise the strict periodicity would not be observed, but why it is so short-lived is a mystery. Isolated and very strong individual pulses have been observed from the nearby pulsar B0656+14 (Weltevrede et al. 2006) which, had the pulsar been more distant, would have been identified as a RRAT. It is possible that RRATs are a terminal stage in the life of a pulsar or that they are a distinct class, possibly different from birth. Their highly intermittent nature makes them very hard to find and consequently there is likely to be a large undetected population of them in the Galaxy, maybe comparable to the population of ordinary pulsars.

These recent discoveries highlight the fascination of pulsars. Even after nearly 40 years, these incredibly precise clocks continue to surprise us with their diversity and unexpected properties. It is an interesting contrast that these most predictable of objects continue to be so unpredictable!

**References**


Burgay, M., D’Amico, N., Possenti, A., A., Manchester, R. N., Lyne, A. G., Joshi, B. C., McLaughlin, M. A., Kramer, M., Sarkissian, J. M., Camilo, F., Kalogera, V., Kim, C. & Lorimer, D. R. 2003, Nature, 426, 531.

Camilo, F., Ransom, S. M., Halpern, J. P., Reynolds, J., Helfand, D. J., Zimmerman, N. & Sarkissian, J. 2006, Nature, in press (astro-ph/0605429).

Crawford, F., Gaensler, B. M., Kaspi, V. M., Manchester, R. N., Camilo, F., Lyne, A. G., & Pivovaroff, M. J. 2001, ApJ, 554, 152.

Kaspi, V. M. & McLaughlin, M. A. 2005, ApJ, 618, L41.

Lorimer, D. R. & Xilouris, K. M., 2000 ApJ, 545, 385.

Lyne, A. G., Burgay, M., Kramer, M., Possenti, A., Manchester, R. N., Camilo, F., McLaughlin, M. A., Lorimer, D. R., D’Amico, N., Joshi, B. C., Reynolds, J. & Freire, P. C. C. 2004, Science, 303, 1153.

Kramer, M., Stairs, I. H., Manchester, R. N., McLaughlin, M. A., Lyne, A. G., Ferdman, R. D., Burgay, M., Lorimer, D. R., Possenti, A., D’Amico, N., Sarkissian, J. M., Reynolds, J. E., Freire, P. C. C. & Camilo, F. 2006, Nature (submitted).

Malofeev, V. M., Malov, O. I., Teplykh, D. A., Tyul’Bashev, S. A. & Tyul’Basheva, G. E. 2005, Astron. Reports, 49, 242.

McLaughlin, M. A., Kramer, M., Lyne, A. G., Lorimer, D. R., Stairs, I. H., Possenti, A., Manchester, R. N., Freire, P. C. C. and Joshi, B. C., Burgay, M., Camilo, F. & D’Amico, N. 2004, ApJ, 613, L57.

McLaughlin, M. A., Lyne, A. G., Lorimer, D. R., Kramer, M., Faulkner, A. J., Manchester, R. N., Cordes, J. M., Camilo, F., Possenti, A., Stairs, I. H., Hobbs, G., D’Amico, N., Burgay, M. & O’Brien, J. T. 2006, Nature, 439, 817.

Stairs, I. H., Manchester, R. N., Lyne, A. G., Kaspi, V. M., Camilo, F., Bell, J. F., D’Amico, N., Kramer, M., Crawford, F., Morris, D. J., McKay, N. P. F., Lumsden, S. L., Tacconi-Garman, L. E., Cannon, R. D., Hambly, N. C. & Wood, P. R. 2001, MNRAS, 325, 979.

Weltevrede, P., Stappers, B. W., Rankin, J. M. & Wright, G. A. E. 2006, ApJ (in press).



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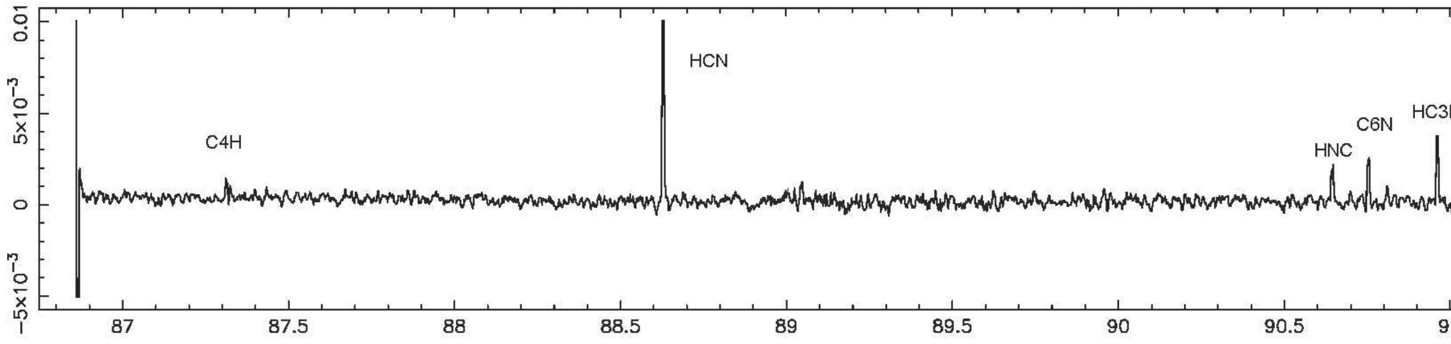



**Figure 1: An example spectrum from 87 – 95 GHz, taken using the new broadband MOPS system towards the carbon star and its circumstellar envelope, IRC+10216. A few of the important lines are clear even from only 200 sec on-source. The full spectrum, taken in seven, 8 GHz-wide bands and extending from 74 to 118 GHz, would span 1.85 metres!**

Continued from page 1

processing firmware, i.e. the code which defines how the FPGAs are programmed, was developed by Dick Ferris and Scott Saunders. It is the fact that the FPGAs can be loaded with different firmware for different applications which gives the MOPS system its versatility. Raji Chekkala, Troy Elton, Jennifer Lie and Jamie Daw also made significant contributions to the construction of MOPS.

The spectrometer has an overall bandwidth of 8.3 GHz. This is divided into four overlapping 2.2 GHz sub-bands in a conventional analogue filter and down-conversion system. Each sub-band is digitised in 2-bit samplers operating at the Nyquist sampling rate. The digital data is then fed to the signal processing section, where polyphase digital filterbank processing divides the band into a large number of independent output frequency channels. Two modes are currently available. A wideband mode provides 1024 frequency channels over each 2.2 GHz sub-band, on two polarisations. A narrowband mode offers a choice of up to four 138 MHz wide “zoom” bands within each 2.2 GHz sub-band. It provides 4096 frequency channels on each zoom-band, with up to16 zoom-bands which can be placed at chosen locations throughout the full 8.3 GHz frequency range.

## Installation and first results

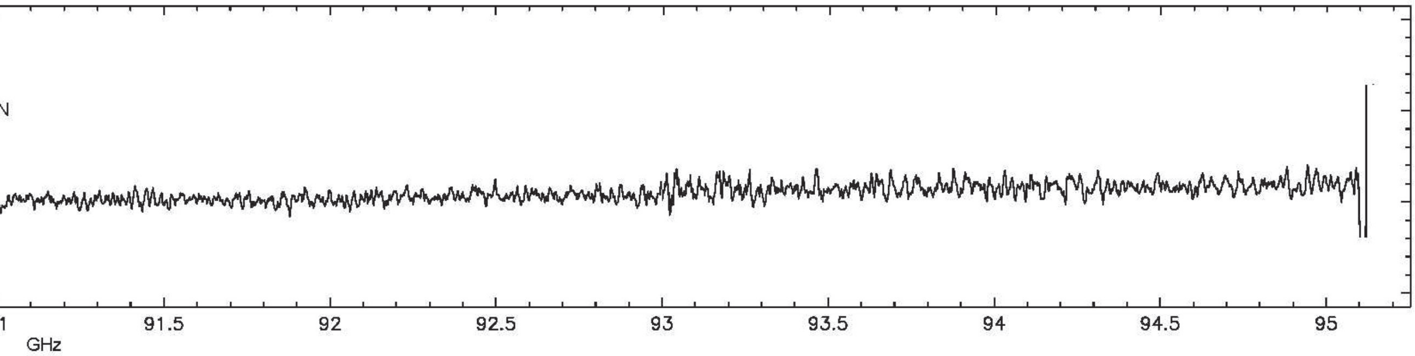
The installation was rather straightforward, being completed in two days in mid-May. First light observations of the complete system were made towards Orion KL, on Monday 22 May 2006.

MOPS may be operated in a ‘broad band mode’ to provide simultaneous access to a completely contiguous 8 GHz range, with 6 km/s channel spacing (at 90 GHz). This kind of configuration is optimal for extragalactic studies, although it will also prove invaluable in obtaining simultaneous, multi-frequency emission-line measurements.

As a test, short (200 s) observations of the circumstellar envelope of the carbon star IRC+10216 have been made across the full 74 – 118 GHz scope of the front-end system at seven offset frequencies. A short part of completely surveyed band is shown in Figure 1, with the stronger transition lines marked (note that at the scales shown here, the plotted results from the entire surveyed range would stretch across 1.85 m!).

A second operational mode allows each of the four 2.2 GHz sub-bands to be configured with 4 x 138 MHz “zoom” windows, each with 4000 channels. The beauty of this mode, and the real draw-card for astro-chemists, is that the centre frequencies of the zoom windows will now be completely configurable within each of the 2 GHz windows, providing simultaneous observations of up to 16 different molecular lines across the 8 GHz range of MOPS, at a velocity resolution of ~0.115 km/s (at 90 GHz). This configuration is optimal for Galactic studies, as is evidenced by the rapid progress of the CHaMP (Census of High and Medium mass Protostars) survey which is in the beginning stages of a simultaneous, multi-frequency series of observations of proto-stellar molecular cores.

Some preliminary results from the CHaMP project (and MOPS zoom mode) are shown in Figure 2. These measurements show the integrated $N_2H^+$




brightness of an example molecular core as the colour scale, overlaid with contours of integrated $HCO^+$ brightness. Both molecules are excited under similar conditions (critical densities ~$10^5$ $cm^{-3}$), but $HCO^+$ is most likely to be optically thick, while $N_2H^+$ is probably optically thin. This means that $HCO^+$ tends to be brightest where there is local heating, while the $N_2H^+$ peaks up near the column density peak. As it turns out, there is a luminous IRAS source right at the $HCO^+$ peak in the image, supporting the above interpretation. While the hot $HCO^+$ peak denotes the site of newly-formed stars, the $N_2H^+$ peak is possibly a site of star formation in an earlier evolutionary phase. CHaMP intends to measure more than 100 cores with MOPS, at up to 10 different lines simultaneously — a process which would otherwise require years of observing time on any other telescope.

With the newly updated receiver system, and now the new, versatile and broad-band Mopra spectrometer, we look forward to a very prosperous future for the Mopra telescope.

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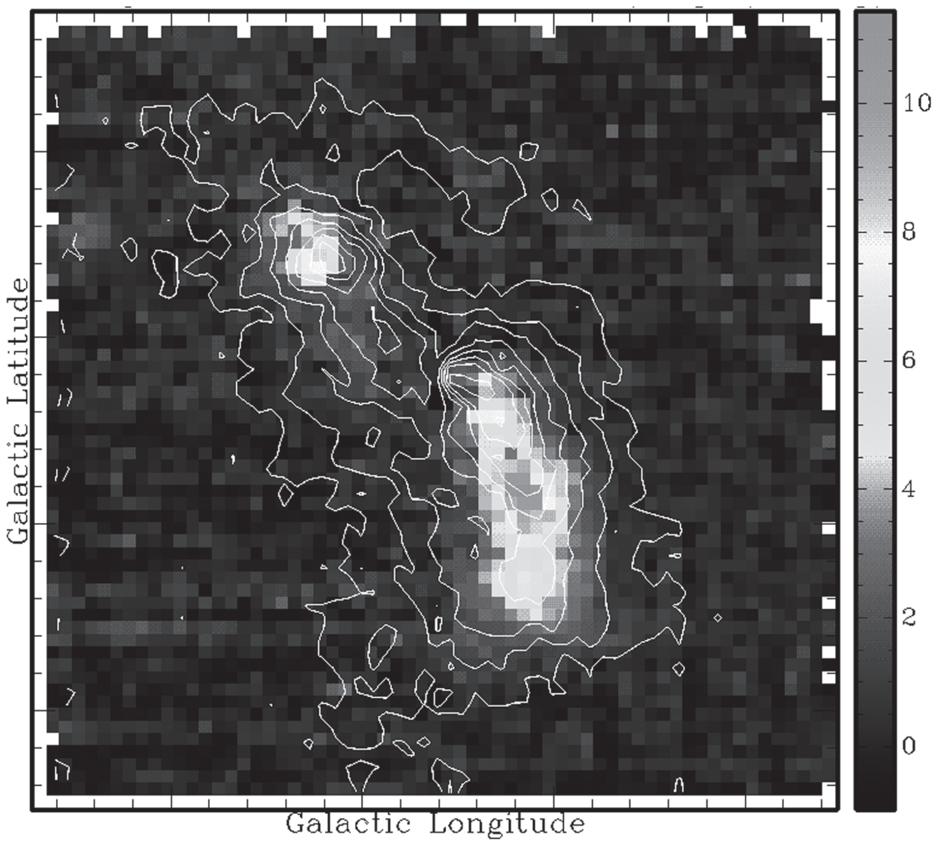


**Figure 2: A map of a CHaMP target – a protostellar core, observed at $N_2H^+$ and $HCO^+$ simultaneously. It will soon be possible to observe up to 16 lines simultaneously, accelerating multi-frequency observations of chemically interesting objects such as this one.**

# Investigating grain growth in southern protoplanetary disks

Many young stars are surrounded by disks of gas and dust which are a natural by-product of the star formation process. It is within these disks that planets can form. While the exact details of planet formation remain uncertain, we do know that sub-micron sized grains must clump and coagulate together to eventually form objects $10^{13} - 10^{14}$ times larger. Because most star forming regions are located at least 150 pc from the Earth and new born stars are usually obscured from our view inside of dark dusty clouds, we cannot directly observe planets forming. However, examining the physical environment and evolutionary timescales of protoplanetary disks can help us constrain models of planet formation.

Young stars often exhibit an infrared excess above that expected from the stellar photosphere, which is successfully modelled by a pre-main-sequence star surrounded by a disk (Adams et al. 1987). The infrared excess emission is produced by small micron-sized grains in the surface layers of the inner regions (<1 AU) of the disk which are heated by the central star. Infrared surveys of young stellar clusters have found that this inner disk emission vanishes within a few million years (Haisch et al. 2001) either because the disk has dissipated or because the opacity drops as the grains grow in size. One would like to differentiate between these two possibilities in order to constrain the timescales of planet formation.

Observations at millimetre and longer radio wavelengths probe the colder outer regions of the disk which are inaccessible at infrared wavelengths. Therefore surveys of the millimetre continuum around young stars are needed to understand the temporal evolution of the outer regions of protoplanetary disks where the majority of the mass resides. Carpenter et al. (2005) find a decrease in the amount of cold dust emission by 10 – 30 million years, but again cannot distinguish between a decrease in the amount of disk material with time or changes in the opacity due to grain growth. Numerical simulations by Tanaka et al. (2005), however, suggest that grain growth and settling can explain the decrease in observed millimetre fluxes on timescales of a few million years without depletion of the disk.

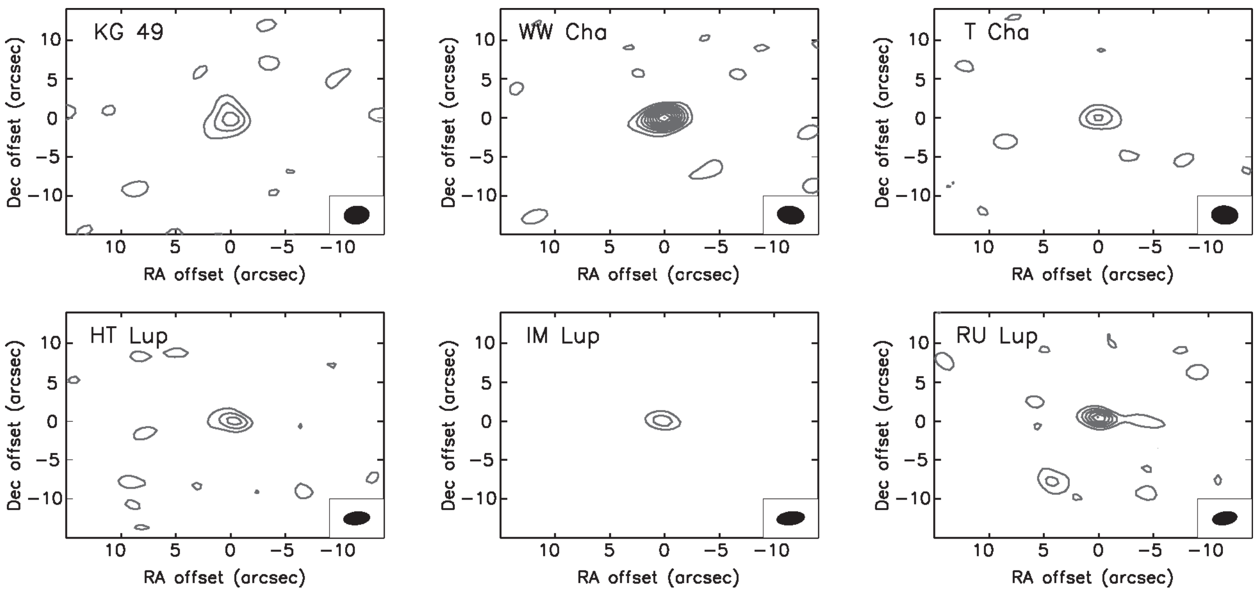


**Figure 1: 3.3 mm continuum emission of six of our detected sources, three from Lupus and three from Chamaeleon. The contours are in 2, 4, 6, 10, 15 and 20 times the RMS noise level. The mm and IR peaks are well correlated.**

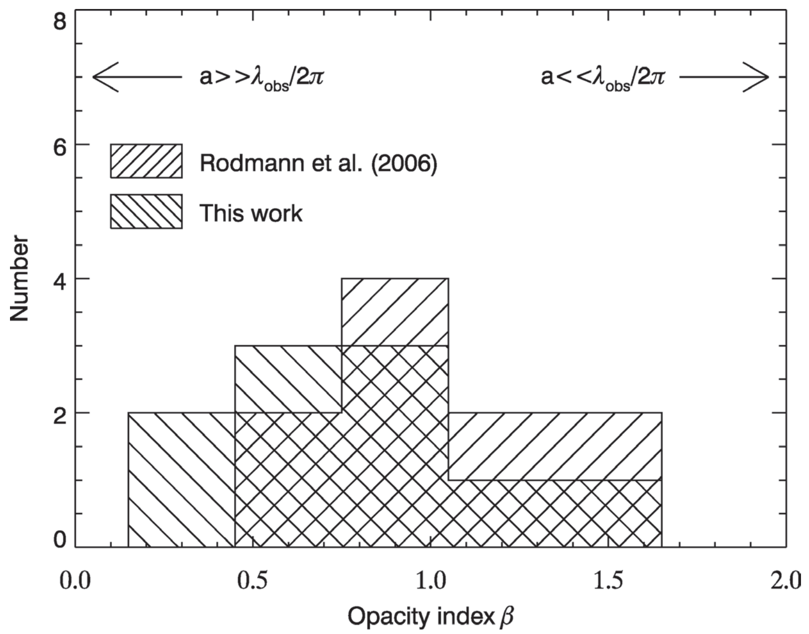


**Figure 2: Histogram of opacity index, β, values from our nine sources plus those of Rodmann et al. (2006).**

While surveys of infrared excess and millimetre continuum in stellar clusters tell us about the general lifetime of disks (or the evolution of grains emitting at those wavelengths), we would ideally like to see more direct signatures of grain growth. One way to do this is by studying the 10 micron silicate band emission. Grain growth can be inferred from the observed correlation between the shape and strength of the silicate band, going from strong, peaked spectra at ~9.8 microns to weaker, flatter spectra extending to longer wavelengths (~11.3 microns) as grains grow (Meeus et al. 2003, Przygodda et al. 2003). However, grain growth and crystallisation have a similar effect on the shape of the 10 micron feature. The presence of crystalline silicates in the spectra of young, intermediate mass Herbig Ae/Be stars (Malfait et al. 1998) and young, low mass T Tauri stars (Honda et al. 2003) indicate substantial processing of grains in protoplanetary disks, due to heating processes. To distinguish between grain growth and crystallisation, Kessler-Silacci et al. (2006) conducted a study of 47 young stars with disks with the Spitzer Space Telescope, covering a larger spectral region (from 5 to 35 microns) in order to detect distinct spectral features of crystalline silicates beyond 10 microns. As well as spectral signatures of crystalline forsterite at 11.3 micron in about one third of their sources, they also found longer wavelength crystalline silicate features (at 28 microns and 33 – 35 microns) in the spectra of over half of their objects. However, the 10 and 20 micron amorphous silicate features dominated the spectra of most sources. Analysing the shape versus strength of the 10 and 20 micron features, Kessler-Silacci et al. (2006) concluded that amorphous grain growth could be seen in the majority of these disks.

Grain growth in protoplanetary disks can also be inferred by determining the millimetre slope of the spectral energy distribution (SED). The SEDs of T Tauri stars show that the (sub)mm fluxes decline more slowly with wavelength than expected for small (~0.1 micron) sized interstellar grains. This shallower wavelength dependence is consistent with optically thin emission from millimetre-sized grains (Beckwith & Sargent 1991) and therefore can be used to indicate grain growth. (However, it has been noted by Dutrey et al. (1996) that the disks need to be spatially resolved to break the degeneracy in fitting the SED for small optically thick disks with small grains and extended optically thin disks with larger grains). If the emission is predominantly optically thin, the spectral energy index, α (where $F_\nu \propto \nu^\alpha$) can be directly related to the opacity index, β (where

| Source | Flux (mJy/beam) | RMS (mJy/beam) | mm slope ($\alpha_{mm}$) | $\beta$ estimate $\beta_e = \alpha_{mm} - 2$ | Opacity index $\beta = \beta_e (1 + \Delta)$ |
|---|---|---|---|---|---|
| **IM Lup** | 8.9 | 1.3 | 3.1 | 1.1 | 1.3 |
| **RU Lup** | 12.7 | 1.0 | 2.6 | 0.6 | 0.7 |
| **HT Lup** | 8.3 | 1.1 | 2.5 | 0.5 | 0.6 |
| **WW Cha** | 25.9 | 1.2 | 2.6 | 0.6 | 0.7 |
| **T Cha** | 6.4 | 1.0 | 2.8 | 0.8 | 1.0 |
| **KG 49** | 11.9 | 1.5 | 2.3 | 0.3 | 0.4 |

**Table 1: Continuum fluxes at 3.3mm, RMS, millimetre slope $\alpha_{mm}$ and opacity index $\beta$ for three of our Lupus sources (IM Lup, RU Lup and HT Lup) and three of our Chamaeleon sources (WW Cha, T Cha and KG 49). Note that the fluxes are from point-source fitting in the u-v plane.**

$k_v \propto \nu^\beta$) and grain sizes can be inferred from the opacity law. The millimetre spectral slope $\alpha$ is related to the opacity index $\beta$ via b = ($\alpha$-2)(1+$\Delta$), where $\Delta$ is the ratio of the optically thick to optically thin disk emission (Beckwith et al. 1990). For grains a few tenths of a micron $\beta$~2, while for much larger grains $\beta$~0. Particles about the same size as the observing wavelength will have intermediate $\beta$ values.

Over the past four years we have been undertaking a 3 mm continuum survey with the Compact Array of disks around nearby young stars (both T Tauri and Herbig Ae/Be stars) in the southern sky to investigate the evolution of protoplanetary disks and grain growth. The goals of our project are to obtain fluxes and hence spectral energy indices, as well as resolve disk structures to probe the physical conditions and help constrain disk models. For our results on the resolved sources TW Hya and HD 100546, see Wilner et al. (2003). Here we present preliminary results from the successful 2005 millimetre season. We observed 14 southern T Tauri sources (ten in Chamaeleon and four in Lupus), detecting nine sources at the 3-$\sigma$ level and obtaining strict upper limits for a further three sources. See Figure 1 for 3 mm continuum maps of a sample of our survey. From these detections we have estimated the disk mass of the systems, which range from $1.4 \times 10^{-2} - 2.8 \times 10^{-3}$ $M_\odot$ (which is comparable to the minimum mass solar nebula). By combining our 3 mm fluxes with 1.3 mm fluxes from the literature (Reipurth et al. 1993, Henning et al. 1993, 1998) we have derived the millimetre spectral energy indices, $\alpha$, and hence the opacity indices, $\beta$. Using characteristic values of various disk parameters, Rodmann et al. (2006) estimate that $\Delta$~0.2 and hence we find $\beta \approx 1$ for our sources. See Table 1 for $\alpha$ and $\beta$ values for a sample of our sources. Figure 2 shows a histogram of $\beta$ values for the majority of our sources. Plotting the visibility amplitude as a function of baseline length indicates that at least some of our sources are indeed resolved. Thus these opacity indices suggest the presence of mm-sized dust aggregates and hence grain growth in the disks.

Ideally we would like to determine the mm slope of the SED, $\alpha_{mm}$, by using Compact Array 3 mm and 12 mm fluxes (and hopefully one day 7 mm Compact Array fluxes), rather than having to rely on the 1.3 mm single dish fluxes which may include contributions from the ambient material around the sources. A future aim of our project is to obtain the 12 and 7 mm fluxes with the Compact Array, as well as to image the brightest disks with longer baselines to look for changes in the spectral indices as a function of disk radius.

Seven of our sources overlap with the Spitzer sample of Kessler-Silacci et al. (2006), and we have 3-$\sigma$ detections for five of these. The broad 10 and 20 micron amorphous silicate features are seen in all sources, further supporting the notion of grain growth in these disks. By doing a detailed comparison of the $\beta$ values from our study with the infrared spectra of the sources, we can search for correlations to gain a better understanding of grain growth within protoplanetary disks. A similar study of 26 Herbig Ae/Be stars by Acke et al. (2004) found a correlation between the (sub-) millimetre spectral index and the ratio of the near-IR to mid-IR excess, which they interpreted as a relation between the disk geometry and grain size.

The full results of our survey will be presented in Lommen et al. (in prep.) and a detailed study of the resolved source WW Cha will be discussed in Maddison et al. (in prep.).

The authors wish to thank Tony Wong of ATNF/UNSW for all his initial collaboration on this project and help with the 3 mm system, both with the observing and data reduction, especially in the early years of the Compact Array millimetre upgrade.

**References**

Acke, B., van den Ancker, M.E., Dullemiond, C.P., van Boekel, R., Waters, L.B. 2004, A&A, 422, 621

Adams, F.C., Lada, C.J., Shu, F.H. 1987, ApJ, 312, 788

Beckwith, S.V.W., et al. 1990, AJ, 99, 924

Beckwith,S.V.W., Sargent, A.I. 1991, ApJ, 382, L31

Carpenter, J.M., Wolf, S., Schreyer, K., Launhardt, R., Henning, T. 2005, AJ, 129, 1049

Dutrey, Guilloteau, Duvert et al. 1996, A&A, 309, 493

Haisch, K.E., Lada, E.A., Lada, C.J. 2001, ApJ, 553, L153

Henning, Th., Pfau, W., Zinnecker, H., Prusti, T. 1993, A&A 276, 129

Henning, Th., Burkert, A., Launhardt, R., Leinert, Ch., Steeklum, B. 1998, A&A, 336, 565

Honda et al. 2003, ApJ, 585, L59

Kessler-Silacci, J. et al. 2006, ApJ, accepted (astro-ph/0511092)

Malfait, K., et al. 1998, A&A 332, L25

Meeus, G., Sterzik, M., Bouwman, J., Natta, A. 2003, A&A, 409, L25

Przygodda, F., et al. 2003, A&A, 412, L43

Reipurth, B., Chini, R., Krugel, E., Kreysa, E., Sievers, A. 1993, A&A 273, 231

Rodmann, J., Hennig, Th., Chandler, C.J., Mundy, L.G., Wilner, D.J. 2006, A&A, 446, 211

Tanaka, H, Himeno, Y., Ida, S. 2005, ApJ, 625, p414

Wilner, D.J., Bourke, T.L., Wright, C.M., Jorgensen, J.K., van Dishoeck, E.F., Wong, T. 2003, ApJ, 596, 597

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# Regular items

## ATNF outreach

### ATNF teacher workshops

The first half of 2006 has seen the ATNF conduct three workshops for teachers, two in NSW and one in WA.

*Astronomy in Your Classroom and Beyond* was held in Geraldton, WA from 17 – 19 March. Modelled on the successful teacher workshops previously held at Parkes, the event attracted 20 teachers from the Mid West region and Perth. The workshop was organised in conjunction with the Office of Science and Innovation with support from Scitech through their Australian Schools Innovation in Science, Technology and Mathematics (ASISTM) grant *Astronomy in WA*, the Mid West Development Commission and Perth Observatory. Workshop sessions included talks by Dr Ray Norris, Dr George Hobbs and Lance Taylor with practical sessions by Rob Hollow. A highlight was a stunning viewing night held at Nunkara Farm accompanied by a wonderful barbecue dinner. A magnificent moonrise was an additional treat.

A one-day workshop, *Astrophysics for Physics Teachers* was held at our Marsfield headquarters in April. This was focused on the content and activities teachers need to deliver the Astrophysics option in the NSW HSC Physics course.

The annual *Astronomy from the Ground Up!* workshop at Parkes on 19 – 21 May was attended by 18 teachers and two staff members from the Parkes Visitors Centre. Speakers included David Malin, Fred Watson (Anglo-Australian Observatory) and David McKinnon (Charles Sturt University) as well as ATNF staff and some of the participating teachers. As well as the lectures, participants learnt how to run a viewing night and find their way around the night sky. Highlights included a walk on the surface of the Dish and tour of the telescope and a sumptuous "Dinner by the Dish" at the Parkes *Dish Café*.

Participants at all of our workshops return home with a wealth of resources and ideas for use with their students.

Photo: Robert Hollow

**Figure 1: Participants in *Astronomy in Your Classroom and Beyond* in Geraldton tackling one of the classroom activities.**

Photo: Robert Hollow

**Figure 2: Teachers viewing the Sun safely at the workshop at Parkes.**

### ASISTM project *Wildflowers in the Sky*

The ATNF has been awarded an ASISTM grant by DEST for its *Wildflowers in the Sky* project. Fewer than 25% of applications were successful in receiving funding. The *Wildflowers* project will involve ATNF staff visiting and working closely with five partner schools in the Mid West region of WA in astronomy education. The partner schools are Cue Primary School, John Willcock College in Geraldton, Meekatharra District High School, Meekatharra School of the Air and Pia Wadjarri Remote Community School. Other partner institutions are Charles Sturt University through their Remote Telescope Project, Scitech in Perth and The Office of Science Technology and innovation in the WA Department of Industry and Resources.

The first stage of the project is a teacher professional development training day that takes place in Cue in late June. The Project Coordinator, Rob Hollow, and two ATNF astronomers will then visit each of the schools in August during National Science Week. A second school tour is planned for March 2007. They will work with teachers and students to develop new materials for use with the partner schools, other schools in WA and beyond. The materials and resources developed as part of the project will be made available to other schools via the web. The professional development of teachers will help them more effectively convey astronomical concepts in the classroom. Students will have the chance to meet and interact with professional scientists and be exposed to possible career paths in science and engineering. Schools will receive small optical telescopes for observations and other resources. This exciting and challenging project will see the profile of astronomy rise in the region and provide a valuable educational experience for the students and teachers involved.

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# Parkes Observatory report

## Operations

Operations have again continued to be largely trouble free. The unusually hot and blustery weather experienced from November 2005 to March this year has abated, and lost time to wind has been very low of late. Time lost for the year-to-date has been 3.3% to wind, and <0.5% to equipment faults, with no single faults of particular note.

## Methanol multibeam receiver

The methanol multibeam receiver is operating to specifications and is now in routine use. The second frequency chain is now fully commissioned with all 28 channels (seven beams x two polarisations x two frequencies) now operational in both the multibeam spectral line correlator and the pulsar analogue filterbank.

One minor but nagging problem emerged from the February session of the 6 GHz pulsar survey — a 10-second periodic modulation of the receiver power on all beams, in the form of a sharp negative-going spike. This problem was identified as originating in the receiver monitoring and has since been eliminated.

The main Galactic methanol survey (P502) has been discovering new masers at close to the predicted rate, confirming the performance of the system. The survey is also able to piggy-back on the 6-GHz pulsar survey to obtain deeper integrations over a reduced area of sky, thanks in large measure to a new hybrid multibeam/wideband correlator configuration devised by Warwick Wilson.

It is now possible to switch between the 20-cm multibeam and methanol multibeam receiver (when both are installed) at the flick of a switch in the downstairs control room. This remote control (of all 13 and 7 beams on the two respective receivers) is the result of work by Tim Ruckley and Jeffrey Vera.

## Upgraded observatory network access

The installation of a new high-speed fibre link to the Observatory was completed in March and the new connection was used to very good effect during the March and May long baseline sessions, with continuous near-real-time fringe verification between Parkes, Mopra and Narrabri now almost a routine matter. This has had an enormously benificial impact on the ease and reliability of VLBI observations.

At present the link is not available for general observing or purposes other than VLBI, pending finalisation of the contract between CSIRO and Australian Academic Research Net (AARNet).

## Quarters

The long-awaited opening of the new kitchen at the observers quarters took place on Friday 31 March 2006. The new and much larger kitchen marks the first serious upgrade to catering facilities at the observators quarters for many many years. Work is now well underway in converting the old kitchen space into an expanded dining area. These works will improve the overall experience of observatory dining for visitors, at the same time making the quarters an easier and more pleasant place to work for staff.

Thanks to all involved in getting the new kitchen up and running, including Barry Turner and his site services team of Ken Reeves, Tom Lees, Jon Crocker, Scott Brady and the late Colin Grover. Many thanks also the the kitchen staff of Janette Cole, Shirley Ingram and Anne Evans for their energetic cooperation and their forbearance with the numerous problems along the way.

A special tribute is due to the late Colin Grover, who died tragically while on holidays in January before he could see the fruits of his efforts at the quarters fully-realised.

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# Compact Array and Mopra report

## Staff

The departures from Narrabri of Bob Sault, Ravi Subrahmanyan, Lakshmi Saripalli, John Giovannis and Maxim Voronkov were mentioned in the last ATNF News. Needless to say, the accompanying loss of on-site expertise has required extra effort from staff and some understanding and patience from observers. In recent months we have welcomed Dion Lewis as Mopra Operations Scientist and Brett Lennon as Systems Administrator. I started as Officer-in-Charge at the beginning of May, and would like to to thank all ATNF staff, and those at Narrabri in particular, for the warm welcome my family and I have received. During this transitional period the efforts of all staff have been outstanding, with the work of Brett Hiscock as Acting OiC, Mark Wieringa as Assistant OiC and Robin Wark in providing the majority of after-hours on-site support particularly notable.

The World's Greatest Shave and World's Biggest Morning Tea were well supported again this year. The staff members appearing tonsorially-challenged in recent weeks are those who raised the most for the Leukemia Foundation, with the fund-raising for the Cancer Council ensuring lunch was superfluous for many on the day!

## Compact Array systems

Work has been ongoing for two problems experienced with the 12-mm receivers: moisture condensing on the dewar windows, and an "ice" build-up in the dewars. A dry air system has been trialled successfully on one antenna to circumvent the first problem and it is now being extended to all antennas. The build-up of ice in the dewars requires a modification which is planned to take place when the receivers are taken off the antennas for the 7-mm installation. In the interim, receivers displaying this problem have been warmed as a temporary solution.

The millimetre observing season started on 20 April. The weather has, thus far, been good, but several niggling instrumental problems have arisen. CA05 has a notably higher $T_{sys}$ and lower gain than the other four antennas. Testing to isolate the problem is underway: if needs be, there is a two week period towards the end of June with no mm observing scheduled during which the receiver can be removed and worked on.

CA01 and, to a lesser extent, CA02, have had occasional recurrences of the azimuth oscillation problem seen last year. The drive systems are complex feedback systems and the regular checking and adjustment has not been able to eliminate this problem. A more detailed monitoring of the interplay between the feedback loops involved in the drive systems is underway.

Synchronisers have now been installed on the generators of CA01–05 with the installation of CA06 and Mopra to occur in July. These units will allow the generators to synchronise with mains power and will allow a seamless transfer of power to and from the generator. This will negate the need to interrupt observing when switching between power sources and will provide improved monitoring of the antenna power systems.

## CloudSat

CloudSat is a satellite in a near-polar orbit at 705 km altitude with a 99-minute period. It carries a pulsed, 1.8 kW, narrow-band, 94.05 GHz radar feeding a downward-looking, high-gain, off-axis parabolic antenna. CloudSat was launched on 28 April 2006 and its radar was switched on on 2 June. (Some background to the allocation of this frequency to active space research is given at *www.iucaf.org/CloudSat/*.) Calculations indicate that there should be little impact on observations unless the satellite passes directly overhead while the mm receivers are on axis and the telescope at zenith. The Antenna Control Computers (ACCs) at the Compact Array and Mopra have been modified and will now not let the telescopes be parked with the mm systems on axis. This may be extended so that the telescopes cannot be stowed with the mm systems on axis either. Millimetre-band observers will be warned of upcoming passes near zenith to ensure they are not tracking near zenith at these times.

### 7-mm upgrade

A delegation from NASA visited Narrabri on 29 May to inspect the site and discuss the installation of the 7-mm receivers for satellite tracking. One of the issues for the satellite tracking is that during routine astronomical observing a 51-millisecond duration synchronisation sequence is included in every (nominally 10 second) correlator cycle. This 0.51% data loss is acceptable for astronomers, but is not to those for whom every bit counts. Tests of a modified unit that enables this "blanking" to be switched off have been successful, and production of these for all antennas is underway. Installation of the prototype 7-mm receiver on antenna 6 is planned for late July, and this should be able to be carried out with little impact on observers. The full installation will be carried out over the first four months of next year and, as noted in the call for proposals for the October semester, some impact on observing is unavoidable: 12-mm observing will not be possible in the first four months of next year, and there will be several periods of a week or so in which only four antennas will be available.

### Mopra issues

The lightning strike at Mopra in January, reported in the previous ATNF news, damaged a broad range of systems, however repairs were able to be completed in time for the first observations at the end of April. The experience is enabling a more robust system to be put in place just in case lightning does strike twice! The VLBI run in mid-May coincided with first light for the new 12-mm system at Mopra. As indicated in Figure 1, measurements of $T_{sys}$ across the band indicate the system is working well. Observations by Jürgen Ott at 27 GHz, shown in Figure 2, have resulted in it being dubbed the new 11-mm receiver. A linear to circular polarisation conversion unit was also installed for the VLBI observations.

It had been anticipated that, starting with this observing season, observations with the Mopra telescope would be able to be conducted remotely from Narrabri. However, the agreement providing access to the optical fibres linking the ATNF sites have not yet been signed, and so we are not yet able to offer this. As it is unclear what timescale this will be resolved on, observers have been advised to continue planning to travel to Mopra for observing.

For a combination of several reasons, the Mopra

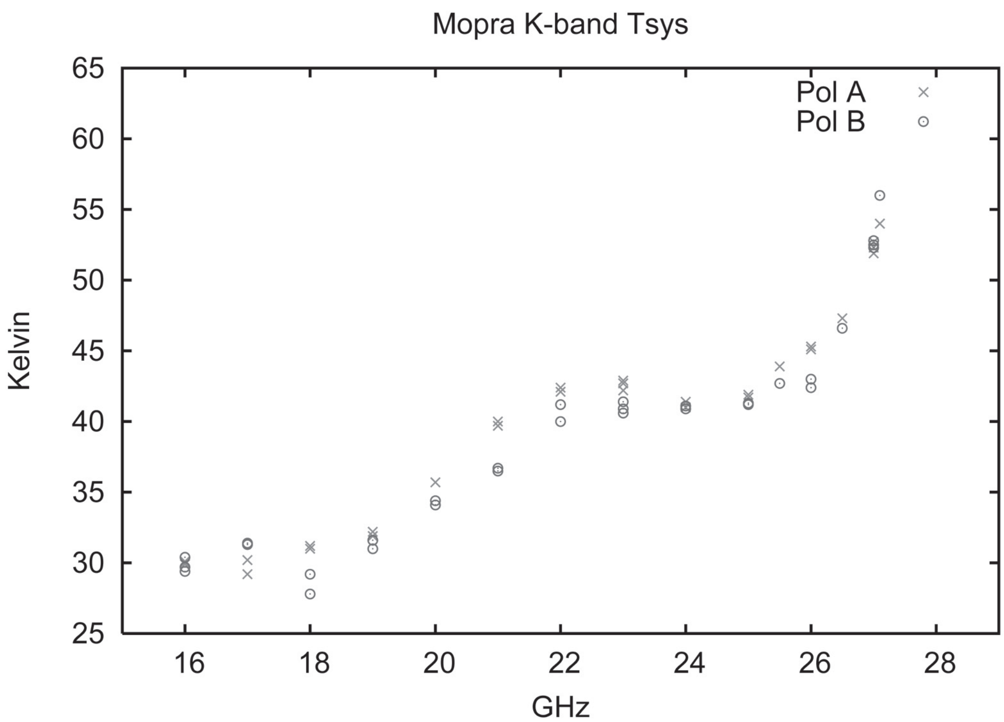


**Figure 1: K-band system temperature measurements for the Mopra telescope**

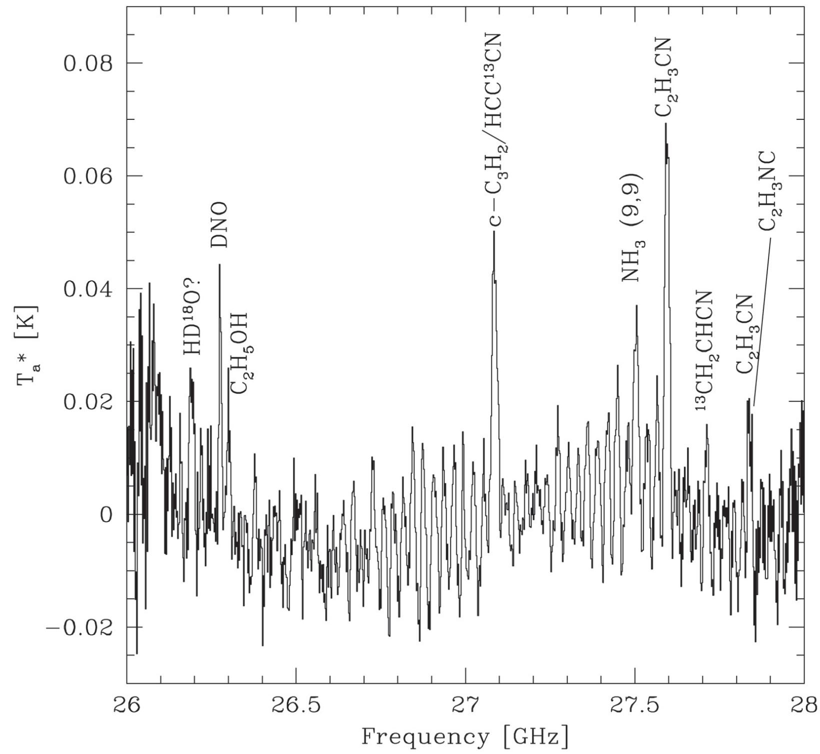


**Figure 2: A Mopra spectrum towards Sgr B2 with preliminary line identifications marked, indicating the good performance of the 12-mm receiver at the 11-mm end of the spectrum. The underlying ~30 MHz ripples are an artefact, the source of which is currently under investigation. Also, as the noise diode at 12-mm is not yet calibrated, the $T_a^*$ scale is preliminary (figure courtesy J Ott).**

Induction Weekend for this year was cancelled, however observers have been assured that Dion Lewis, the new Mopra Operations Scientist, will be available to provide all the necessary observer support. Observers have been encouraged to arrive a day or two before their observations to become familiar with the new hardware and software systems, and to coordinate travel plans with Dion as far in advance as possible so that he is able to provide the best possible support.

As described elsewhere in this issue, the installation of the full MOPS system is now complete, and Warwick Wilson and his team are to be congratulated for providing this fantastic new capability.

## Infrastructure

The design of the major refurbishment/extension of the Narrabri Control Building is nearing completion with the tender documents due for completion later this month. The planned building incorporates improved RFI shielding and a number of environmentally friendly design aspects and will provide a safer, more comfortable, and more efficient facility for staff and observers. Unfortunately, financial pressures on CSIRO's capital investment program have resulted in the funding for the construction being delayed by at least a year. Repairs and maintenance which had been put off under the expectation the building would proceed are now being prioritised for the coming months.

## Outreach

The installation of new panels and displays at the Narrabri Visitors Centre has been completed and an opening ceremony for the redeveloped Centre will take place during the Narrabri Observatory Open Day on 29 July 2006. Efforts are underway to bring a number of the displays inside the centre up-to-date before then too. There have been four visits to the Observatory in recent months from film crews, and segments with Ernie Dingo and Mike Whitney went to air in late April.

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# Time assignment information

## Compact Array configurations

The Compact Array configuration cycle described in last October's ATNF news is being followed for the coming semesters. This cycle does not include an H75 configuration in the October 2006 semester. However, as the April semester ends with an H75 array, it will be possible to schedule proposals requesting this array at the beginning of the October semester. H75 is an important configuration for mm observers requiring short baseline data for calibration purposes, and if there is sufficient demand, it may be possible to repeat this in future years.

## Time allocation and publications

The allocation of time on ATNF facilities is done purely on the basis of scientific merit. Figure 1 below shows the time allocated at the Compact Array, as a percentage of the total allocated time, for proposals where the principle investigator (PI) is at the ATNF or another Australian institution, and where the PI is overseas. The time allocation for the Parkes radio telescope is similar to the Compact Array; typically 40% of time is allocated to proposals with an overseas PI.

Figure 2 shows the number of publications in refereed journals for papers that include data taken with ATNF facilities. The publication counts are shown for papers where the first author is in Australia and where the first author is overseas. In 2005, 119 papers with ATNF data were published in refereed journals.

A comparison of the two figures shows the stronger performance of projects that have an overseas PI. In 2005 64% of refereed papers had a first author at an overseas institution. However, most projects involve teams with both Australian and international partners. In 2005, for example, Australian authors were included on 87% of refereed publications.

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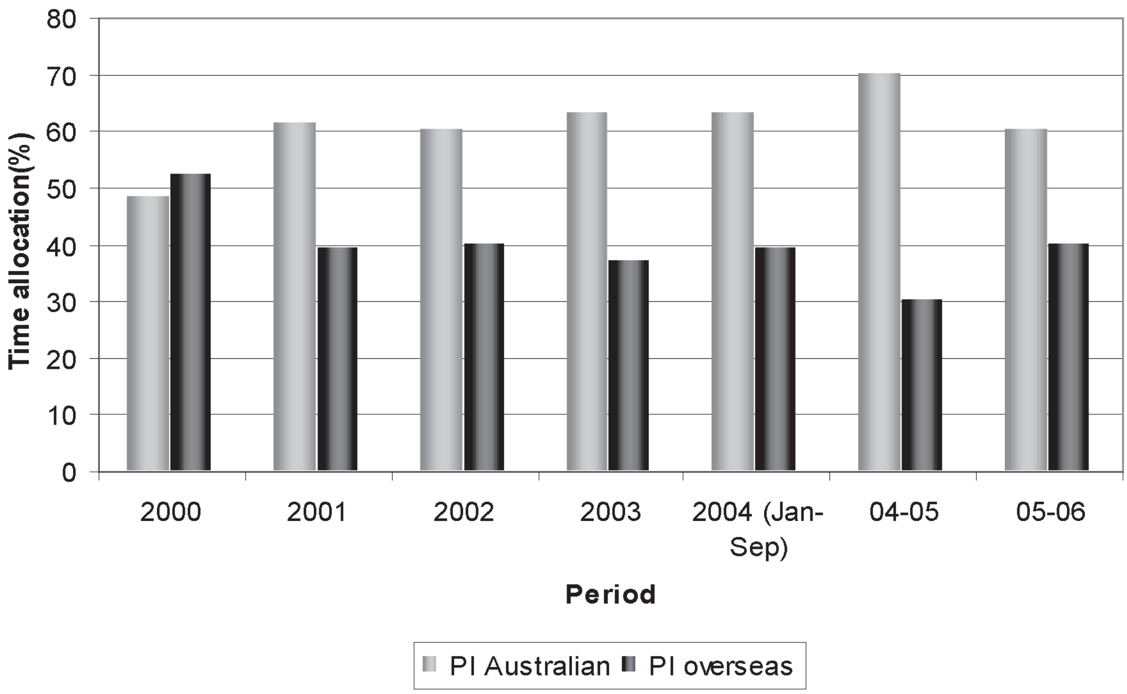


**Figure 1: Compact Array time allocation, 2000 – 2006**

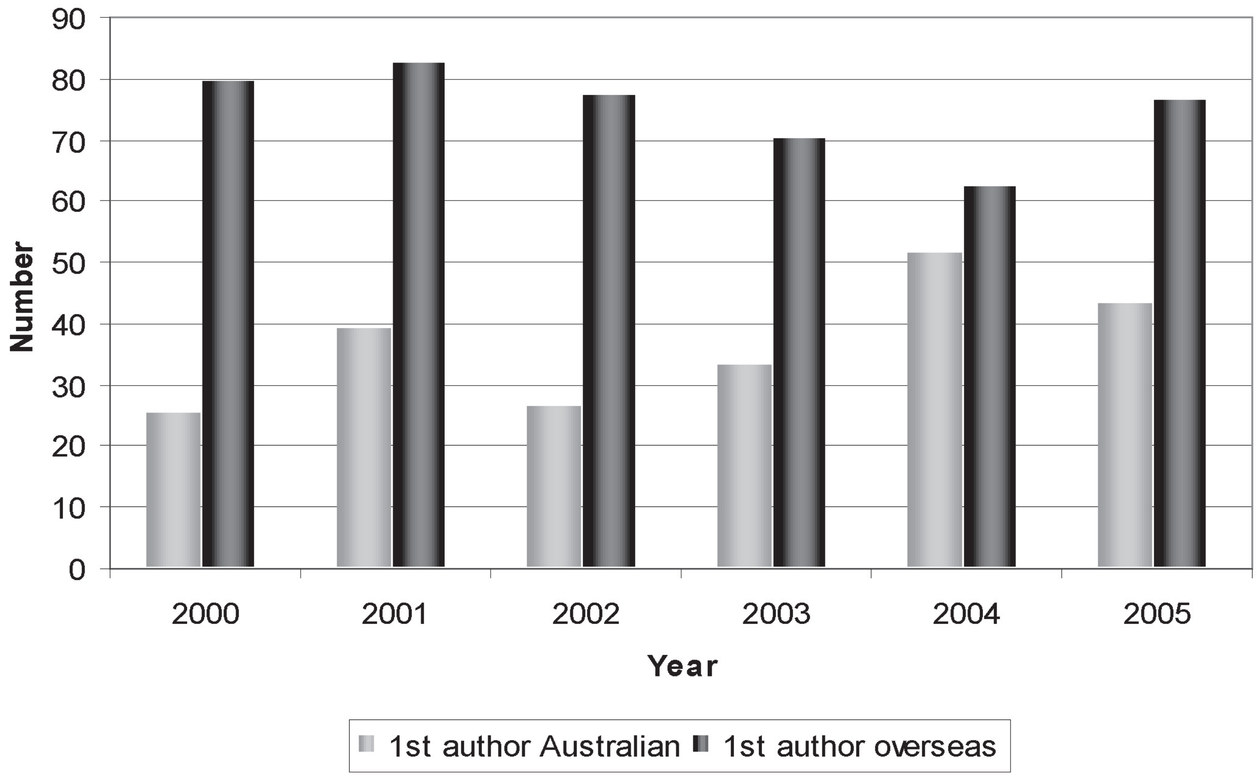


**Figure 2: Publications from data obtained with ATNF facilities, 2000 – 2005.**

# ATNF publications list

Publication lists for papers which include ATNF data or ATNF authors are available on the Web at *www.atnf.csiro.au/research/publications*. Please email any updates or corrections to this list to Christine van der Leeuw. This list includes published refereed papers compiled since the February 2006 newsletter. Papers which include ATNF staff are indicated by an asterisk.

*AFONSO, J., MOBASHER, B., KOEKEMOER, A., NORRIS, R.P. & CRAM, L. "Optical and X-ray identification of faint radio sources in the GOODS CDF-S Advanced Camera for Surveys field". AJ, 131, 1216-1230 (2006)

* BAINS, I., WONG, T., JONES, P., ...LONGMORE, S., ...VORONKOV, M. et al. "Molecular line mapping of the giant molecular cloud associated with RCW 106. I. 13CO". MNRAS, 367, 1609-1628 (2006).

*BENAGLIA, P., KORIBALSKI, B.S. & ALBACETE COLOMBO, J.F. "Radio detection of colliding wind binaries". PASA, 23, 50-63 (2006).

*BRIGGS, F.H. & BARNES, D.G. "H I 21 cm observations of the PG 1216+069 sub-damped Lya absorber field at z=0.00632". ApJ, 640, L127-L130 (2006).

*BURGAY, M., JOSHI, B.C., D'AMICO, N., POSSENTI, A., LYNE, A.G., MANCHESTER, R.N., MCLAUGHLIN, M.A., KRAMER, M., CAMILO, F. & FREIRE, P.C. "The Parkes High-Latitude pulsar survey". MNRAS, 368, 283-292 (2006).

BURGESS, A.M. & HUNSTEAD, R.W. "The Molonglo Southern 4 Jy sample (MS4). I. Definition". AJ, 131, 100-113 (2006)

BUSFIELD, A.L., PURCELL, C.R., HOARE, M.G., LUMSDEN, S.L., MOORE, T.J.T. & OUDMAIJER, R.D. "Resolving the kinematic distance ambiguity of southern massive young stellar object candidates". MNRAS, 366, 1096-1117 (2006)

*CARRAD, G., SYKES, P. & MOOREY, G.G. "A cryogenically cooled, seven beam, 21 cm wavelength receiver front end for the Arecibo radio telescope". In: Workshop in Applications of Radio Science (WARS2006), Leura, NSW, 15-17 February, (2006)

*CHERNYAKOVA, M., NERONOV, A., LUTOVINOV, A., RODRIGUEZ, J. & JOHNSTON, S. "XMM-Newton observations of PSR B1259-63 near the 2004 periastron passage". MNRAS, 367, 1201-1208 (2006).

DE BLOK, W.J.G. & WALTER, F. "The stellar population and interstellar medium in NGC 6822". AJ, 131, 343-362 (2006)

*DODSON, R., VORONKOV, M.A. & ELLINGSEN, S.P. "Erratum: 'A search for 4750- and 4765-MHz OH masers in southern star-forming regions'". MNRAS, 366, 1119-1120 (2006)

*EKERS, R.D. "Paths to disovery in radio astronomy". In: Workshop in Applications of Radio Science (WARS2006), Leura, NSW, 15-17 February, (2006)

*FERETTI, L., BACCHI, M., SLEE, O.B., GIOVANNINI, G., GOVONI, F., ANDERNACH, H. & TSAREVSKY, G. "Diffuse radio sources in the cluster of galaxies Abell 548b". MNRAS, 368, 544-552 (2006)

FERRARIO, L. & WICKRAMASINGHE, D. "Modelling of isolated radio pulsars and magnetars on the fossil field hypothesis". MNRAS, 367, 1323-1328 (2006).

*GLAZEBROOK, K., VERMA, A., BOYLE, B., OLIVER, S., MANN, R.G. & MONBLEAU, D. "Anglo-Australian Telescope imaging and microslit spectroscopy in the southern Hubble Deep Field". AJ, 131, 2383-2393 (2006).

*GREISEN, E.W., CALABRETTA, M.R., VALDES, F.G. & ALLEN, S.L. "Representations of spectral coordinates in FITS". A&A, 446, 747-771 (2006)

*GUIRADO, J.C., MARTI-VIDAL, I., MARCAIDE, J.M., CLOSE, L.M., ALGABA, J.C., BRANDNER, W., LESTRADE, J.F., JAUNCEY, D.L., JONES, D.L., PRESTON, R.A. & REYNOLDS, J.E. "On the dynamics of the AB Doradus system". A&A, 446, 733-738 (2006)

*HAN, J.L., MANCHESTER, R.N., LYNE, A.G., QIAO, G.J. & VAN STRATEN, W. "Pulsar rotation measures and the large-scale structure of the Galactic magnetic field". ApJ, 642, 868-881 (2006).

*KAARET, P., CORBEL, S., TOMSICK, J.A., LAZENDIC, J., TZIOUMIS, A.K., BUTT, Y. & WIJNANDS, R. "Evolution of the X-ray jets from 4U 1755-33". ApJ, 641, 410-417 (2006).

KALEMCI, E., TOMSICK, J.A., ROTHSCHILD, R.E., POTTSCHMIDT, K., CORBEL, S. & KAARET, P. "The galactic black hole transient H1743-232 during outburst decay: connections between timing noise, state transitions, and radio emission". ApJ, 639, 340-347 (2006).

*KARASTERGIOU, A. & JOHNSTON, S. "Absolute polarization position angle profiles of southern pulsars at 1.4 and 3.1 GHz". MNRAS, 365, 353-366 (2006)

*KNIGHT, H.S., BAILES, M., MANCHESTER, R.N., ORD, S.M. & JACOBY, B.A. "Green Bank Telescope studies of giant pulses from millisecond pulsars". ApJ, 640, 941-949 (2006).

*KONDRATKO, P.T., GREENHILL, L.J., MORAN, J.M., LOVELL, J.E.J., KUIPER, T.B.H., JAUNCEY, D.L. et al. "Discovery of water maser emission in eight AGNs with 70 m antennas of NASA's Deep Space Network". ApJ, 638, 100-105 (2006)

*KRAMER, M., STAIRS, I.H., MANCHESTER, R.N., McLAUGHLIN, M.A., LYNE, A.G., FERDMAN, R.D., BURGAY, M., LORIMER, D.R., POSSENTI, A., D'AMICO, N., SARKISSIAN, J., JOSHI, B.C., FREIRE, P.C. & CAMILO, F. "Strong-field tests of gravity with the double pulsar". Annal. Physik, 15, 34-42 (2006)

*LORIMER, D.R., STAIRS, I.H., FREIRE, P.C., CORDES, J.M., CAMILO, F., FAULKNER, A.J., LYNE, A.G., NICE, D.J., RANSOM, S.M., ARZOUMANIAN, Z., MANCHESTER, R.N., .... HOBBS, G.B., et al. "Arecibo pulsar survey using ALFA. II. The young, highly relativistic binary pulsar J1906+0746". ApJ, 640, 428-434 (2006).

*MATTHEWS, D., STAVELEY-SMITH, L. & DYSON, P. "High-resolution observations of the Magellanic Stream". In: Workshop in Applications of Radio Science (WARS2006), Leura, NSW, 15-17 February, (2006)

*McCLURE-GRIFFITHS, N.M., FORD, A., PISANO, D.J., GIBSON, B.K., STAVELEY-SMITH, L., CALABRETTA, M.R., DEDES, L & KABERLA, P.M.W. "Evidence for chimney breakout in the Galactic supershell GSH 242-03+37". ApJ, 638, 196-205 (2006)

*McLAUGHLIN, M.A., LYNE, A.G., LORIMER, D.R., KRAMER, M., FAULKNER, A.J., MANCHESTER, R.N., CORDES, J.M., CAMILO, F., POSSENTI, A., STAIRS, I.H., HOBBS, G., D'AMICO, N., BURGAY, M. & O'BRIEN, J.T. "Transient radio bursts from rotating neutron stars". Nature, 439, 817-820 (2006)

MINIER, V. & LINEWEAVER, C. "A search for water masers toward extrasolar planets". A&A, 449, 805-808 (2006).

*MIZUNO, N., MULLER, E., MAEDA, H., KAWAMURA, A., MINAMIDANI, T., ONISHI, T., MIZUNO, A. & FUKUI, Y. "Detection of molecular clouds in the Magellanic Bridge: candidate star formation sites in a nearby low-metallicity system". ApJ, 643, L107-L110 (2006).

*MOOREY, G.G., AXTENS, P., BOWEN, M., DUNNING, A., GOUGH, R., GRAVES, G.R. & KANONIUK, H. "A 77-117 GHz radioastronomy receiver frequency conversion and local oscillator system". In: Workshop in Applications of Radio Science (WARS2006), Leura, NSW, 15-17 February, (2006)

*MOOREY, G.G., BOLTON, R., DUNNING, A., GOUGH, R., KANONIUK, H. & REILLY, L. "A 77-117 GHz cryogenically cooled receiver for radioastronomy". In: Workshop in Applications of Radio Science (WARS2006), Leura, NSW, 15-17 February, (2006)

*MURPHY, T., LAMB, P., OWEN, C. & MARQUARDING, M. "Data storage, processing, and visualization for the Australia Telescope Compact Array". PASA, 23, 25-32 (2006)

*PURCELL, C.R. , ... ROBERTSON, S. et al. "A CH3CN and HCO+ survey towards southern methanol masers associated with star formation". MNRAS, 367, 553-576 (2006).

*REID, W.A., PAYNE, J.L., FILIPOVIC, M.D., DANFORTH, W.A., JONES, P.A., WHITE, G.L. & STAVELEY-SMITH, L. "An ATCA radio-continuum study of the Small Magellanic Cloud. IV. A multifrequency analysis of the N 66 region". MNRAS, 367, 1379-1393 (2006).

*REYNOSO, E.M., DUBNER, G., GIACANI, E., JOHNSTON, S. & GREEN, A.J. "The interior of the SNR RX J0852.0-4622 (Vela Jr) at radio wavelengths". A&A, 449, 243-250 (2006).

RYAN-WEBER, E.V. "Cross-correlation of Lyman alpha absorbers with gas-rich galaxies". MNRAS, 367, 1251-1260 (2006).

*SCHWARTZ, D.A., MARSHALL, H.L., GELBORD, J., PERLMAN, E.S., GEORGANOPOULOS, M., BIRKINSHAW, M., WORRALL, D.M., LOVELL, J.E.J., JAUNCEY, D.L. et al. "The remarkable X-ray jet in the quasar 4C 20.24". In: Proceedings of the X-Ray Universe Symposium, El Escorial, Spain, 26-30 September, 2005, ESA Special Pub., SP-604, 579-584 (2006).

*SCHWARTZ, D.A., MARSHALL, H.L., LOVELL, J.E.J., MURPHY, D.W., BICKNELL, G.V., BIRKINSHAW, M., GELBORD, J., GEORGANOPOLOUS, M., GODFREY, L., JAUNCEY, D.L., PERLMAN, E.S. & WORRALL, D.M. "Chandra observations of magnetic fields and relativistic beaming in four quasar jets". ApJ, 640, 592-602 (2006).

*SUBRAHMANYAN, R., HUNSTEAD, R.W., COX, N.L.J. & McINTYRE, V. "SGRS J0515-8100: a fat-double giant radio galaxy". ApJ, 636, 172-180 (2006)

URQUHART, J.S., THOMPSON, M.A., MORGAN, L.K. & WHITE, G.J. "Radio continuum and molecular line observations of four bright-rimmed clouds". A&A, 450, 625-643 (2006)

*VAN LOON, J.T., STANIMIROVIC, S., EVANS, A. & MULLER, E. "Stellar mass loss and the intracluster medium in Galactic globular clusters: a deep radio survey for H I and OH". MNRAS, 365, 1277-1282 (2006)

WALSH, A.J. & BURTON, M.G. "Mopra observations of G305.2+0.2: massive star formation at different evolutionary stages?". MNRAS, 365, 321-326 (2006)

*WARREN, B.E., JERJEN, H. & KORIBALSKI, B.S. "Stellar and gas properties of high H I mass-to-light ratio galaxies in the local universe". AJ, 131, 2056-2073 (2006).

*WHITING, M.T., WEBSTER, R.L. & FRANCIS, P.J. "Multi-object spectroscopy of the field surrounding PKS 2126-158: discovery of a z=0.66 galaxy group". MNRAS, 368, 341-350 (2006).

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## Mopra Observatory, Coonabarabran

See Paul Wild Observatory

## Outreach Website

outreach.atnf.csiro.au

## ATNF News online

**http://www.atnf.csiro.au/news/newsletter**