ATNF News

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IN THIS ISSUE

Radio emission from the 27 December 2004 giant flare from SGR 1806-20

Neutron stars (NS), in all their forms, provide an unique view into the properties of ultra-dense materials (with core densities possibly exceeding that of atomic nuclei) as well as the physics of extremely high magnetic fields (B ~ 10^{12} – 10^{16} G). Of particular interest are two, probably related, classes of NS – Anomalous X-ray Pulsars (AXPs) and Soft Gamma-ray Repeaters (SGRs). AXPs and SGRs have very different observational properties from those of radio pulsars, namely the lack of pulsed radio emission, very long rotation periods (~ 5 – 12 sec as opposed to ~ 0.002 – 8 sec period of radio pulsars), and frequent bursts (luminosity L ~ 10^{37} – 10^{46} ergs/s in the hard X-ray/soft γ-ray regime, with the "giant bursts" with as high as ~ 10^{46} ergs/s being extremely rare. The currently favoured models for both AXPs and SGRs is that they are "magnetars" – young NS with very high magnetic fields (B ~ 10^{14} – 10^{16} G) whose quiescent emission is due to magnetic field decay, not spin-down as for radio pulsars, and whose bursts are believed to be triggered by "starquakes" on the neutron star's crust.

Until recently, only two giant bursts had been observed – one on 5 March 1979 from SGR 0526-66 and one on 27 August 1998 from SGR 1900+14. While no radio afterglow was detected from the 5 March event, a Very Large Array (VLA) observation seven days after the 27 August event detected a new, faint (0.3 mJy at 8.5 GHz) radio source which disappeared from view after 11 days (Frail et al. 1999). While faint, this radio

Continued on page 19

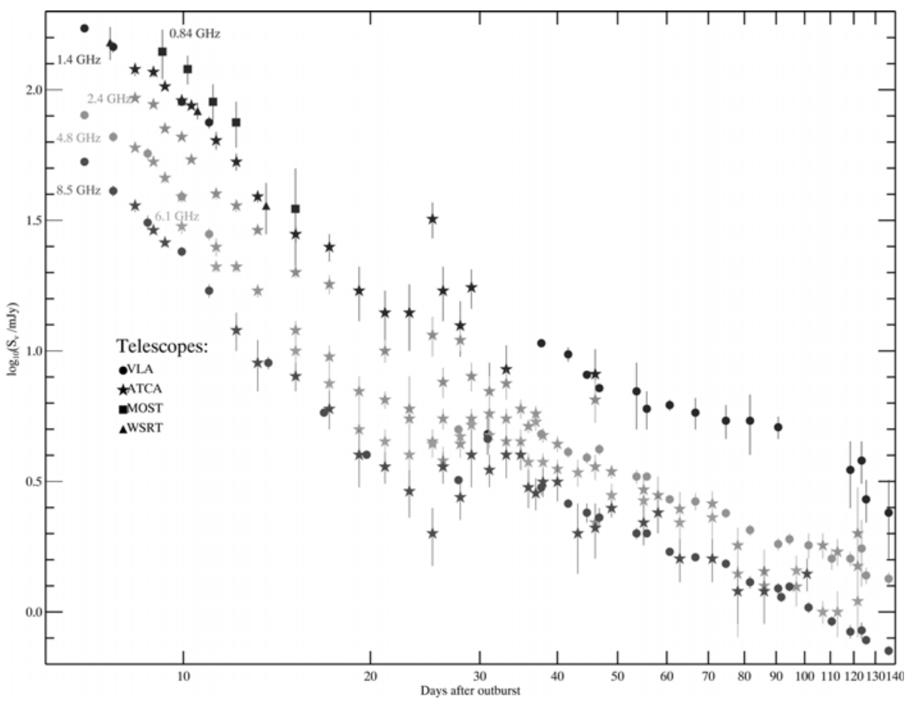

Figure 1: The 0.8, 1.4, 2.4, 4.8, 6.1, and 8.5 GHz light curve of the synchrotron nebula produced by the 27 December giant flare. The data points taken between 6 and 20 days after the flare were originally reported in Gaensler et al. (2005b), while the 4.8-GHz data taken between 20 and 63 days after the flare were originally reported in Gelfand et al. (2005)

Editorial

Welcome to the June 2005 ATNF newsletter.

There was a wonderful response to our call for contributions for this newsletter – we were very pleased to be at the receiving end. We thank all the contributors several of whom also readily agreed to send in articles on request.

The cover article in this issue describes the spectacular outburst from a neutron star, the soft gamma-ray repeater SGR 1806-20 and the significant part played by the Compact Array in this "once-in-a-human-lifetime" event.

On page 18 Ravi Subrahmanyan reports on the innovative design and construction of a telescope for observing the epoch of re-ionization in the early universe. On page 4 Ilana Klamer reports on her discovery of massive amounts of molecular gas in the most distant radio galaxy, TN J0924–2201, the observation being a pointer to more such gas-rich radio galaxies. Read also about the recent Compact Array millimeter observations of central rings of dense molecular gas in a barred spiral galaxy by Tony Wong on page 8.

This issue also brings you a report on a new pulsar timing package by George Hobbs, ATNF outreach and meeting reports and reports from the Observatories. Not to mention the excitement of the "simple" telescope's big find on page 10 by Dave Brodrick.

We hope you enjoy the newsletter. We are always pleased to have your comments and suggestions. You can contact us at *newsletter@atnf.csiro.au.*

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

Lakshmi Saripalli, Jessica Chapman
and Joanne Houldsworth
The ATNF News Production Team
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Contents

ATNF senior management

From 1 July 2005 the ATNF will move to a new management structure, with each of the three themes of the ATNF's activities headed by an Assistant Director. Dave McConnell will take up the new role of Assistant Director: Operations, with responsibility for the Parkes and Narrabri Observatories, the VLBI/LBA efforts and the National Facility Support group. Warwick Wilson and Lister Staveley-Smith will continue to lead the Engineering and Astrophysics themes respectively, with the new titles of Assistant Director: Engineering and Assistant Director: Astrophysics.

Lewis Ball will take up the role of Deputy Director with specific responsibility for ATNF relationships internal to CSIRO, including coordination of ATNF's input to the Science Investment Process, the new mechanism for distributing funding within CSIRO by research theme rather than by Division.

This structure will support changes to the governance of Australia's SKA efforts which are likely to result in the ATNF Director, Brian Boyle, taking on the role of Australian SKA Director, CSIRO assuming the role of contracting body, and ASKACC becoming a CSIRO Advisory Committee.

Lewis Ball
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Online proposal applications

In the last edition of ATNF News (issue 55) we discussed a new web-based application called OPAL that will replace the current system for telescope proposal submissions. OPAL will provide a set of web-based tools to help astronomers prepare and submit their telescope proposals and will also provide additional facilities for administrators, TAC members and telescope schedulers.

A user-specification document for OPAL was released in March 2005. This was extensively reviewed and feedback from astronomers and administrators has been incorporated in the specifications. The software for OPAL is now being written and tested, using a modular approach that allows the application to be developed and tested in manageable sections. OPAL is being written using Java and the Spring Framework and uses an Oracle 9i relational database for data management. The OPAL save file format is based on the Remote Telescope Markup Language (RTML).

We plan to complete the software coding for OPAL in July 2005 and will then spend about one month testing OPAL for robustness and for user acceptance before a full release in early September. Tutorial and help files will be provided on the ATNF web pages and users of ATNF facilities will be encouraged to try out OPAL and become familiar with it. We expect that OPAL will be fully in use for the ATNF applications deadline on 15 December 2005 for the 2006APRS.

Please email any enquiries to Jessica Chapman or Chris Owen.

Jessica Chapman and Chris Owen
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Compact Array discovers molecular gas in the very early universe

The completion of the 12-mm and 3-mm receiver systems on the Compact Array has secured two new astronomical windows into the southern skies. A slew of new scientific observations are now possible. These include investigating the molecular gas reservoirs in and around galaxies in the very distant (high redshift) universe. The quantity and distribution of molecular gas in galaxies highlights their recent star formation as well as pinpointing the production sites for future stellar populations. After molecular hydrogen (H_2), which is very difficult to observe at radio wavelengths, carbon monoxide (CO) is the most abundant molecule in the universe, and on large scales is a very good tracer of H_2. The available Compact Array observing windows for different characteristic transitions of the CO molecule from galaxies over a wide range of redshifts are illustrated in Figure 1.

Powerful radio emission from objects which existed during the first few billion years following the Big Bang pinpoint the sites where the most massive galaxies we see around us today are forming. The highest redshift radio galaxies therefore provide the best clues to the formation epoch of massive galaxies, and observations of molecular gas and stardust in such systems are of crucial importance, as both trace star formation on large scales. Northern hemisphere millimetre interferometers have already observed molecular gas and dust in a handful of high-redshift radio galaxies, confirming that these objects are still forming the bulk of their stars.

The most distant radio galaxy known to date is TN J0924–2201, located more than 12.5 billion light years away at a redshift of 5.2. When first discovered in 1999, it was hypothesised that TN J0924–2201 is a young, primeval galaxy in its formative stages. The detection of molecular gas was needed to confirm prodigious amounts of past and present star formation. Until the millimetre upgrade of the Compact Array, this observation was not possible – the source is either too far south for northern hemisphere millimetre interferometers, or its redshift moves the characteristic CO frequencies out of available observing bands.

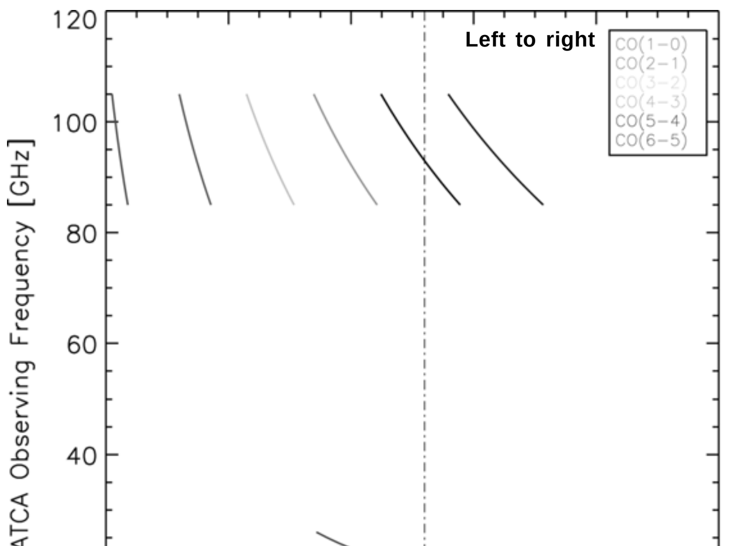

Figure 1: The available observing windows for Compact Array observations of redshifted carbon monoxide. The dashed line indicates the redshift of TN J0924–2201.

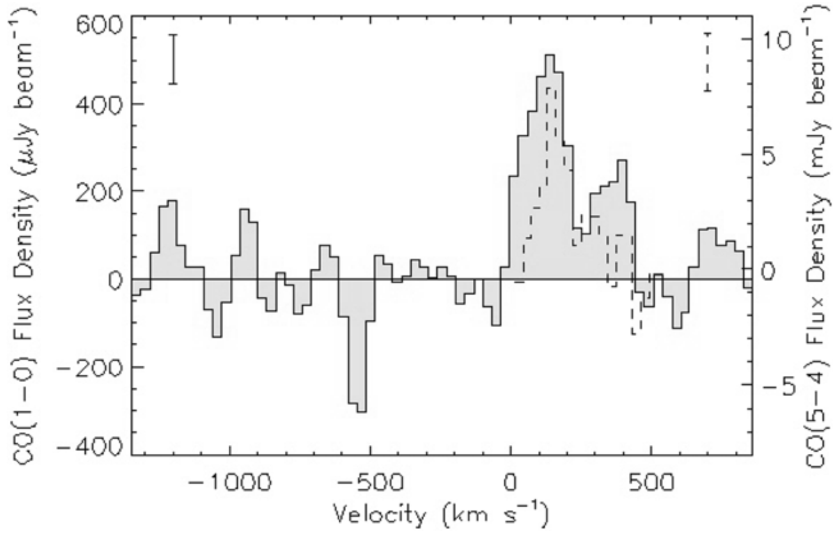

Figure 2: Carbon monoxide emission spectra from the galaxy TN J0924–2201. The J=1–0 transition is shown filled and the J=5–4 transition is overlaid with a dashed line. One-sigma thermal noise bars are shown in the top left and right corners respectively.

In August and September of 2004, the Compact Array discovered about 100 billion solar masses of molecular gas from TNJ0924–2201. The CO (J=1–0) and the CO (J=5–4) emission spectra from TN J0924–2201 are shown in Figure 2. These observations place a stringent upper limit of 1.1 billion years (the time since the Big Bang) on the timescale for the star formation in the galaxy, since we see the by-product in the form of CO. This timescale also limits the formation of the central super-massive (10^9 $M_\odot$) black hole, which we believe to be responsible for the powerful radio emission.

The discovery of molecular gas in this galaxy surprised many members of the high redshift CO community because the quantity of its CO content implied an equally enormous amount of dust – which is so far not observed using sub-millimetre telescopes. The inherent difficulty involved in high-redshift CO observations, coupled to a limited amount of time allocated to observe such targets, has caused astronomers to fine-tune their samples of galaxies in order to maximise the chances of success. Since molecular gas and dust are both by-products of star formation, and generally trace each other well, the traditional selection technique has been to observe only the immensely dusty objects on the premise that they will be the only ones with equivalently enormous amounts of CO. In fact, the massive content of molecular gas in TN J0924–2201 was discovered *in spite* of its lack of dust. This is the third such object where molecular gas has been detected without pre-selection on dust, hinting that many more such galaxies remain to be discovered.

I Klamer (University of Sydney), R. D Ekers (ATNF), R W Hunstead (University of Sydney) and E M Sadler (University of Sydney) (*klamer@physics.usyd.edu.au*)

Ron Ekers elected to Royal Society

Professor R D (Ron) Ekers, the ATNF's Foundation Director and an ARC Federation Fellow, has been elected a Fellow of the Royal Society in the UK for his contributions to radio astronomy and the development of techniques for the field.

Ron's research interests include extragalactic astronomy, galactic nuclei and the techniques of radio astronomy. A hallmark of his career has been wide-ranging, innovative experiments. Former colleague Seth Shostak of the SETI Institute once described Ron as having "more ideas per unit time than anybody [else] I have encountered".

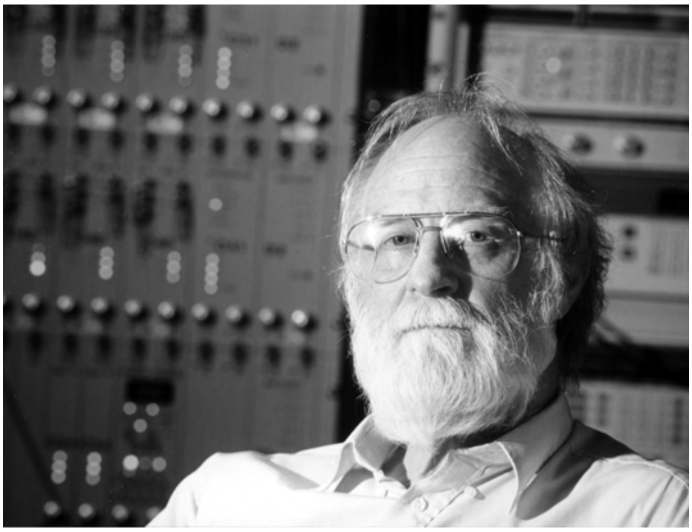

Photo: Brad Collis

Professor Ron Ekers

Ron, however, considers that at least part of his success was due to the good fortune of being in the right place at the right time. "All I did was to exploit the great telescopes and take advantage of research opportunities built up by the scientists and engineers who developed radio astronomy in Australia," he says.

After gaining his PhD from the Australian National University in 1967, Ron worked at the California Institute of Technology; the Institute of Theoretical Astronomy in Cambridge, UK; and at the Kapteyn Laboratory in Groningen, The Netherlands. Then, at the age of 39, he was recruited to become the first director of the VLA.

In 1987 Ron returned to Australia, headhunted again, to become the first director of the Australia Telescope National Facility; a role he continued in until he received a Federation Fellowship in 2003.

Ron has been Chairman of a number of international bodies: the International Union of Radio Science Commission J, which deals with radio astronomy; the International Steering Committee of the Square Kilometre Array radio telescope, the world's largest radio telescope now being planned by 17 countries; and the Anglo-Australian Telescope Board, which is responsible for the largest optical telescope in Australia. He is currently president of the International Astronomical Union.

In 1993 Ron was elected a Fellow of the Australian Academy of Science and a Foreign Member of the Royal Dutch Academy of Science; in 2003 he became a Member of the American Philosophical Society. In 2005 he was awarded the Australian Academy of Science's Flinders Medal for research in the physical sciences.

Ron joins a small, select group of Royal Society Fellows associated with Australian radio astronomy. Edward "Taffy" Bowen, long-term Chief of the Division of Radiophysics (the ATNF's predecessor) became an FRS; so too did David Martyn, who was RP Chief during 1940 – 1941; Joseph Pawsey, the first head of the radio astronomy group in Radiophysics; and John Bolton, first director of the Parkes Observatory.

Founded in 1660, the Royal Society is the oldest scientific academy in continuous existence. Fellows are elected by peer review, for life, and do not have to be British nationals. The Society has about 1300 Fellows and Foreign Members.

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xNTD news

As outlined in the last newsletter, the New Technology Demonstrator (NTD) is the ATNF's SKA technology demonstrator for wide field-of-view, low frequency solutions. The Extended New Technology Demonstrator (xNTD) builds on these solutions to create a viable scientific instrument. In order to get an overall impression of the science potential of the xNTD, the Australia Telescope Users Committee (ATUC) organised a one-day science workshop "Science with the Extended New Technology Demonstrator", held at the ATNF Marsfield site on 6 April. More than 50 people attended from a broad range of institutions, with representation from Perth, Adelaide, Melbourne, Hobart, Canberra and the Sydney region. There were 15 speakers covering a broad range of science topics; the speakers were asked to evaluate their science within a "strawman" set of specifications for the xNTD. The full agenda can be found on the web at *www.atnf.csiro.au/whats_on/workshops/xNTD/*.

The xNTD is clearly seen as breaking new ground both scientifically and technologically, especially in the area of focal plane arrays, valuable for the way ahead to the SKA. There are clear areas of the technology where international collaborations are being established with a number of partner countries. The development of the Mileura site in Western Australia and opportunities for co-sharing the site with other instruments is seen as a key ingredient to the success of the xNTD.

Some of the scientific goals for the xNTD, as highlighted by the speakers, are as follows:

- Almost nothing is currently known about HI in galaxies at redshifts above 0.1. A single 40 square-degree pointing of the xNTD, if observed for 90 days, would yield in excess of 20,000 HI detections of M* galaxies out to a redshift of 0.2.

- The recent HIPASS survey detected ~ 5,000 galaxies out to z ~ 0.01. A survey of the whole southern sky with the xNTD, lasting 150 days, would detect at least 40,000 HI galaxies with M* galaxies detected to z ~ 0.05.

- A continuum survey of the southern sky would return more than 10^6 sources to a 5σ detection limit of 0.4 mJy in only seven days observing. Such a catalogue can be used e.g. to measure the CMB dipole moment and the integrated Sachs-Wolf effect (expected from dark energy models) at z ~ 1.

- A by-product of the continuum survey is the measurement of polarization for 10,000 sources across the whole sky. This would give an accurate picture of the magnetic field structure of our own Galaxy and start to determine the inter-galactic magnetic field (in combination with red-shift measurements for a small fraction of the polarised sources).

- The xNTD would be extremely powerful for detecting variability at the 1% level for 100-mJy sources and the 10% level for 10-mJy sources across the whole sky, giving for the first time a comprehensive picture of the radio-variable sky.

- A compact configuration for the xNTD could realise a Galactic HI survey to 0.1 K across the southern sky. Science outcomes include unraveling the disk-halo interaction and studies of Galactic halo clouds and high velocity clouds.

- Large scale radio surveys, both in continuum and spectral line, are needed to complement vigorous activities in this area at other wavebands over the next five years.

The meeting was extremely useful for the xNTD project team with vigorous discussion about the required angular resolution and frequency range of the instrument, and the scope of the correlator. Areas of common science between the xNTD and the upgraded Sydney University Molonglo Telescope (MOST) were aired and new possibilities were raised about the potential to apply the focal-plane-array technology to the Parkes telescope. I would like to thank ATUC and the participants for a very productive meeting.

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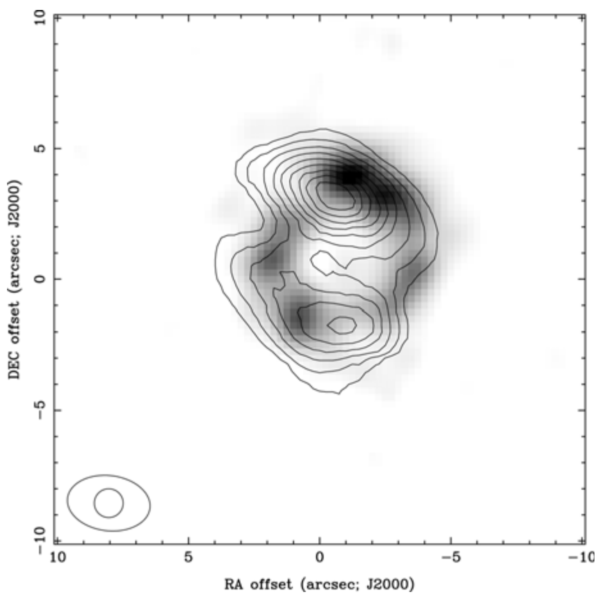
Compact Array images dense gas in a circumnuclear ring

Starbursts are regions of enhanced star formation efficiency, where gas is being converted into stars at much higher rates than can be sustained over billions of years. Aside from merging and dwarf galaxies, one of the most common sites for starbursts is the central kiloparsec of barred spiral galaxies. Such starbursts appear as bright circumnuclear rings in emission tracers of ionised gas such as hydrogen recombination lines or radio continuum. A nice example in the southern sky is the nearby galaxy NGC 7552, which was imaged with the Compact Array at 3 cm by Forbes et al. (1994, AJ 107, 984).

On 9 May we re-observed this galaxy with the Compact Array in the 3-mm lines of HCN and HCO^+. These lines trace the densest molecular gas and thus provide information on where star formation is still in progress. Observations were conducted on a clear, cool day in the H168 configuration and went smoothly. The two lines were observed simultaneously, allowing a direct comparison of their line strengths. Both lines were detected with a signal-to-noise ratio of ~ 6. The images, which show both the rotation velocity of the ring and the distribution of dense gas along it, are among the best produced thus far by the Compact Array at 3 mm.

Although analysis is still in progress and follow-up observations expected later this winter, a few results are already apparent. First, the HCN and HCO^+ peaks do not exactly coincide, even though the two molecules have similar critical densities for excitation. This may be attributable to the dependence of HCO^+ on photochemistry. Second, both molecular tracers display a double or "twin peaks" morphology, which is commonly seen in barred galaxies and has been attributed to crowding of gas orbits as they shift from being oriented parallel to perpendicular to the bar. Third, there doesn't seem to be much gas interior to the ring, consistent with the relative lack of star formation there. This indicates that the inflow of gas along the bar which feeds the ring does not continue on to the nucleus, presumably due to orbital dynamics associated with the inner Lindblad resonance of the bar. Previous studies by Kohno and collaborators suggest that both the weakness of HCN in the nucleus and the low HCN/HCO^+ ratio of about one are consistent with the lack of Seyfert activity in this galaxy – any central black hole is probably "starved" of fuel by the inability of gas to flow inwards.

As the accompanying figures indicate, the dense gas is distributed somewhat differently from the radio continuum emission, which is believed to be mostly non-thermal in origin (Forbes et al. 1994). Since extinction does not affect the radio image, the offset may be related to a time delay between the peaks in the dense gas, which are tied to the pattern speed of the bar, and the locations of recent star formation,



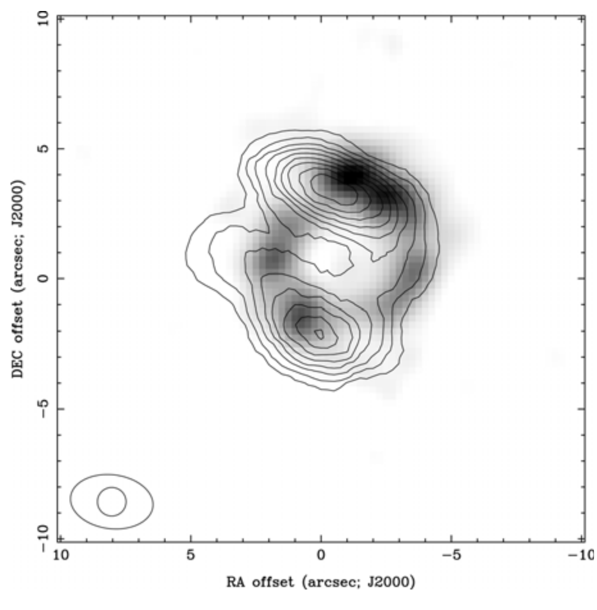


Figure 1: Compact Array 3-cm image of Forbes et al. (1994), recently reprocessed by M. Dahlem (ATNF), overlaid with contours of integrated HCN (left) and HCO^+ (right) emission. The contours are spaced by 10% of the peak intensity starting at 10%. The beam sizes are 1″ at 3 cm and 2″ × 3″ at 3 mm.

which revolve at a different angular velocity. The symmetry of the 3-cm emission suggests that there may be a regular timescale on which bursts of star formation occur. A comparison with recently released *Spitzer Space Telescope* data is currently underway.

We thank the ATNF engineers and Narrabri staff for efforts over the summer which led to significant improvements in the 3-mm receiver temperatures and antenna gains.

Tony Wong (ATNF/UNSW), Stuart Ryder (AAO), Kotaro Kohno (U. of Tokyo) and
Ron Buta (U. of Alabama).
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The Parkes positions/project database

A web interface is now available to an index of Parkes observations. This index is essentially complete for all observations taken at Parkes since 1999, but also includes the large 20-cm multibeam surveys back to 1997.

The URL is *www.parkes.atnf.csiro.au/cgi-bin/utilities/pks_posproj.cgi* or follow “Useful Tools” then “Databases” from the Parkes home page. The interface contains a link to some basic instructions for use, and should be reasonably straightforward for most first-time users. The form contains a link for data requests, and for other related queries and feedback.

Completeness

The index contains observations made with the Parkes observing applications:

- TCS (commissioned in May 1999);
- tkmulti/multi (since mid-1997);
- Multibeam pulsar filterbank (pmctrl/pmdaq).

In general it will not include observations made with:

- the “Spectra” observing program (decommissioned in January 1999);
- the Caltech Pulsar correlator;
- the CPSR1 pulsar baseband recorder (original CPSR);
- the old SPOT or 64M interfaces;
- VLBI or PTI observations;
- any other observations taken with special-purpose user interface.

Scan searching

The algorithm for locating a scan (any observation where the start and stop coordinates differ) will currently match any point in a rectangular box in RA and Dec defined by the scan endpoints. This works well for scans in RA only or Dec only (where the rectangle collapses to a line). A more refined algorithm for better handling of general (diagonal) scans will be implemented soon. Please note that currently no attempt is made to match the coordinates of off-axis beams.

The database will be updated approximately every three months. Comments and/or suggestions should be sent to Stacy Mader.

Stacy Mader
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Small ‘scope catches a big bang

On 4 November 2003 a solar flare occurred that was so large that the X-ray sensors on the NOAA GOES satellites — the defacto standard for quantifying flares since 1974 — saturated for about 12 minutes. Because of this sensor saturation, solar scientists had to try and extrapolate what the peak magnitude and timing might have been, coming up with a preliminary estimate for the peak of soft X-ray flux at 0.1 – 0.8 nm, of X28 (2.8 mW/m^2 at the Earth) peaking at 19:50 UT.

Meanwhile, at the Narrabri Visitor’s Centre, a pair of “RadioJove” kit receivers were assiduously taking 20-MHz flux measurements, which were being recorded to disk on an obsolete PC. This inexpensive radio telescope started as a hobby for local staff, and was described in the article “Narrabri Simple 20-MHz Interferometer” in the October 2002 ATNF News. It turned out that “Simple” made very high fidelity recordings of this exceptional solar flare and we have been able to use these data to better characterise the flare’s X-ray peak.

How is it that this “backyard-class” telescope was able to provide the intensity of solar X-rays some ten billion times higher in frequency than it’s observing band? The answer involves the Earth’s atmosphere acting like a giant X-ray detector: Solar X-rays cause atmospheric molecules to become ionised. As the X-ray intensity increases during large flares, the ionosphere becomes opaque to low-frequency radio waves. The resulting decrease in detected power on the ground is called a sudden ionospheric disturbance, or ionospheric fadeout.

In order to determine the solar X-ray emission from our fadeout data we had to perform several steps:

- Compare the fluxes during the flare to “quiet day” fluxes from the same sidereal times, in order to quantify the ionospheric attenuation of the 20-MHz Galactic background. An instrument that does this is called a relative ionospheric opacity meter, or “riometer”.

- Correct for the solar radiation cross-section of the zenithal ionosphere, in order to ensure our data represented the intrinsic solar X-ray emission, rather than just its local ionospheric effects.

- Use the unsaturated GOES-12 satellite measurements to determine the parameters of fit for a published model that relates low-frequency ionospheric absorption to the solar X-ray intensity.

We have been able to demonstrate that the whole process works by using data from other large “X-class” flares. These flares reveal that, even when we simulate saturation of the GOES-12 sensor, we can still determine the flare peak-magnitude to better than 10% and the peak time to better than three minutes.

Analysis of the 4 November 2003 data was further complicated by the presence of some radio interference at the flare peak. This meant we had to use the additional step of fitting a polynomial to the interference-free data in order to infer the properties at the peak. To reflect the uncertainty associated with this process our error estimate was increased by another 10%.

The end result of this number crunching is a new set of constraints on the magnitude and timing of the largest solar flare on record. Our best estimate gives a peak magnitude of X40 peaking at 19:46 UT. The full range of fits consistent with our data spans X34 – X48, peaking at 19:44-48 UT. This suggests the flare was substantially larger, and peaked earlier, than the X28 preliminary estimate. However our results are comparable to the X28 – X40 (peaking at 19:44-50 UT) and X40 – X50 (at 19:45-46 UT) estimates that have since been published in the literature.

Our observations, described in the paper *X-Ray Magnitude of the November 4 2003 Solar Flare Inferred from the Ionospheric Attenuation of the Galactic Radio Background* have been accepted for publication in the Journal of Geophysical Research and Space Physics.

Just as remarkable as making a scientifically valuable observation with such an inexpensive instrument, was the serendipitous case of “being in the right place at the right time”. An hour earlier and the sun would have been well below the horizon from Narrabri, an hour later and the local ionosphere would have been so highly exposed to the solar X-rays that our technique could not be applied!

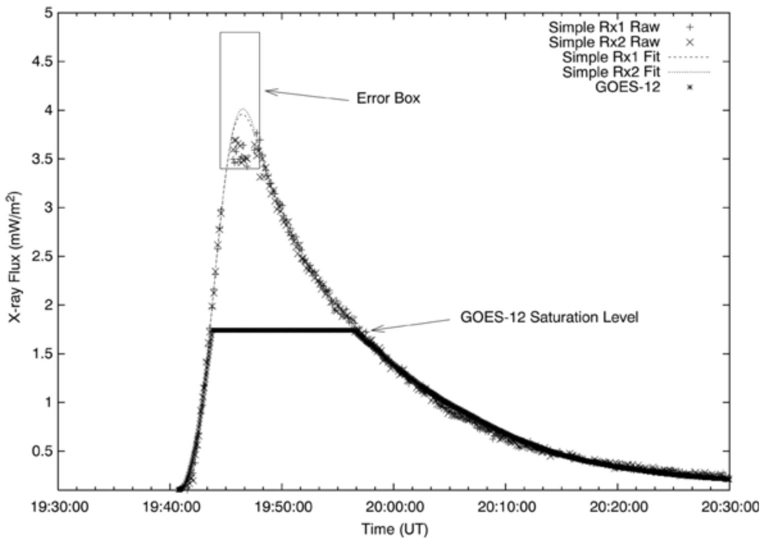

Figure 1: X-ray profile of the largest solar flare on record. The data from the two "Simple" receivers allows us to measure beyond the GOES-12 saturation level and constrain the flare peak to the indicated bounds.

Many people have assisted with this work, including Tim Kennedy, Daron Brooke, Thomas Ashcraft, Rodney Viereck from the NOAA, Rose Roche, Michael Dahlem, Rob Chapman, Charles Belling and Alex Davey. Sincere thanks also go to our anonymous referees.

David Brodrick, Steven Tingay and Mark Wieringa
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(*stingay@astro.swin.edu.au*)
(*Mark.Wieringa@csiro.au*)

Radio Jove is a NASA education and outreach activity. Check out the project at *http://radiojove.gsfc.nasa.gov/*.

Software for a new era of precision pulsar timing

The Parkes Pulsar Timing Array project aims to detect the signatures of gravitational waves in pulsar timing residuals. This requires that pulse arrival times at the Observatory be measured with a random uncertainty of 100 nanoseconds or less. Systematic effects should ideally be kept below one nanosecond. This is an extremely difficult challenge for both observing systems and for data analysis programs.

We have developed TEMPO2, a new pulsar timing package that computes all relevant timing corrections to an accuracy of one nanosecond or better. TEMPO2 is also compliant with the IAU 2000 resolutions on time systems and hence uses up-to-date precession-nutation and polar-motion models, the International Celestial Reference System and Barycentric Coordinate Time. It includes new algorithms to calculate, for example, delays due to the general relativisitic time dilation (Shapiro delay) as a pulse passes the giant planets, second-order Solar Shapiro delay and various atmospheric effects.

The TEMPO2 package includes various analysis and visualisation tools. These include computing and displaying periodograms of the timing residuals, correlating the residuals between different pulsars and graphing the various correction terms computed by TEMPO2. It is also relatively straightforward to develop new "plug-ins" for TEMPO2. Astronomers around the world are already adding features such as a multi-resolution CLEAN deconvolution algorithm and periodicity searches. The TEMPO2 software can be obtained from the webpage *www.atnf.csiro.au/research/pulsar/tempo2*.

We are currently writing three papers that should be submitted shortly. The first contains an overview of the TEMPO2 software and discusses the differences between this software and earlier pulsar timing packages. The second paper contains full details of the timing model and the third describes the use of TEMPO2 for fitting timing solutions to data for multiple pulsars simultaneously and for investigating correlations in the timing data for different pulsars.

TEMPO2 will supersede all existing pulsar timing packages and provide the accuracy needed for pulsar timing into and beyond the SKA era. It will be an essential part of our effort to make what may be the first direct detection of gravity waves.

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The Inaugural Grote Reber medal

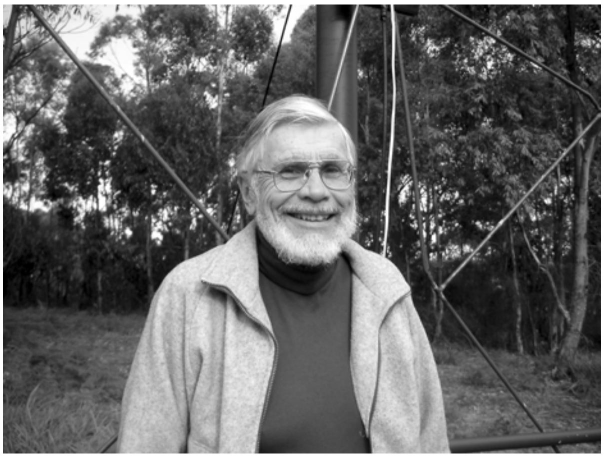

Figure 1: Professor W C Erickson
Courtesy: W Erickson

The inaugural Grote Reber medal is awarded to W C Erickson, (Figure 1) Professor Emeritus at University of Maryland and Honorary Research Associate at the University of Tasmania. Professor Erickson was recognised for his innovative contributions to radio astronomy, especially for his many novel techniques which have been the forerunner of the new generation of metre-wavelength radio telescopes. Currently he operates his own private radio observatory on Bruny Island in Tasmania. Earlier in his career Erickson studied the turbulence in the solar corona, investigated the nature of fast millisecond pulsars and made one of the first detections of very high Rydberg state atoms in the cold interstellar medium. More recently, he has been leading a group of his former students doing sub-arcminute resolution imaging at metre wavelengths.

Professor Erickson was educated at the University of Minnesota and received his PhD degree in 1956. Following appointments at St. Thomas College, Minnesota, the University of Minnesota, the Carnegie Institute and the Convair Corporation, Erickson spent a year in Leiden as the leader of the group developing the Benelux Cross Radio Telescope. While at the University of Maryland from 1963 to 1988, Erickson developed a succession of innovative low-frequency radio telescopes at Clark Lake in the Anza-Borrego Desert in California. Through his students he has left a legacy of skilled scientists who are developing the new generation of metre-wavelength radio telescopes.

The Grote Reber medal will be awarded annually for innovative lifetime contributions to radio astronomy. The medal is administered by the Queen Victoria Museum in Launceston in cooperation with the University of Tasmania, the ATNF and the NRAO. The 2005 prize will be awarded at a ceremony on 8 December 2005 during an international conference on radio astronomy at the University of Tasmania. The medal is to commemorate the pioneering work of Grote Reber, the first radio astronomer (Figure 2). Reber was born on 22 December 1911 in Chicago. In 1937 he built, at his own expense, the first “dish” radio telescope, the forerunner of the Parkes dish, in his back yard in Wheaton, Illinois (Figure 3). Reber made the first surveys of radio waves from the sky and published his results both in engineering and astronomy journals. His accomplishments ensured that radio astronomy became a major field of research. Astronomers in many countries began building bigger and better telescopes to follow up on Reber’s pioneering discoveries.

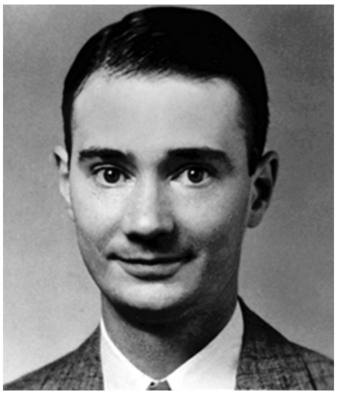

Figure 2: Grote Reber as a young man. This picture is copied from “A Play Entitled the Beginning of Radio Astronomy”, by Grote Reber, in The Journal of the Royal Astronomical Society of Canada, Vol.82, No.3, June 1988, page 93.

Figure 3: The first “dish” radio telescope.
Courtesy: Estate of G Reber

In the 1950s, Reber turned his attention to cosmic radio waves at very low frequencies (1 – 2 MHz, or wavelength 150 – 300 metres), a field neglected by most other researchers. Waves of these frequencies cannot penetrate the Earth's ionosphere except in certain locations at times of low solar activity. To this end he moved to Tasmania, where he lived for many years. There he produced the first sky map at 2 MHz which was made with his square-kilometre array at Bothwell north of Hobart (Figure 4), which is the only square-kilometre array built so far! He died in Tasmania on 20 December 2002.

Figure 4: Grote Reber's square-kilometre array at Bothwell, Tasmania. Courtesy: Estate of G Reber

The award of the Grote Reber medal is made possible through funds provided by the Estate of Grote Reber.

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Results from the 7-mm workshop

The frequency coverage of the Compact Array currently has a rather large gap between 25 and 50 GHz. Since external funding has recently become available to build receivers for this "7-mm" band, a workshop was held on 31 May to explore its scientific opportunities. On sub-galactic scales, the 7-mm band appears optimal to study the poorly constrained theory of the formation of high-mass stars, via observations of radio emission from jets and Ultra-Compact HII regions which signpost the earliest phases in stellar lives. In the later stages of stellar evolution, SiO masers are common in low-intermediate mass stars, being visible throughout the Milky Way and are excellent tracers of galactic dynamics. As an example of using 7-mm observations to study the final stages of stellar evolution, it was reported that the study of SN1987A would profit considerably from the upgrade. It was shown that a vast number of molecular lines exist in this band, many of which are known as valuable probes of density and temperature such as methanol, whilst others are still unexplored or entirely unknown.

In extragalactic astronomy, 7-mm VLBI observations are currently the best compromise of sensitivity and resolution to study AGN cores and jets. International collaborations with KVN, VERA and VLBA appear feasible, as well as Australian-only VLBI observations using the Compact Array, Mopra and Tidbinbilla. On a cosmological scale, the 7-mm upgrade would be invaluable for observations of CO at high redshifts. At almost any redshift between 1.5 and 8, the 7-mm band will not only cover a CO transition of the object, but these transitions would be the easiest to detect with the Compact Array. Furthermore, the 7-mm band would provide data from lower transitions, which are essential when star formation in galaxies at high redshifts is to be modelled. On the largest scale, it was suggested that galaxy clusters could be observed via the Sunyaev-Zeldovich effect, which is a redshift-independent measure of cluster mass. The workshop was widely regarded as a success, and the new ideas will significantly improve the science document for the upgrade. Thanks to all the speakers and participants!

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The VSOP missionaries

In February 1997 a collection of wise-heads in VLBI astronomy could be found in Kagoshima, Japan. They were there to observe the Institute of Space and Astronautical Science (ISAS) launch the first satellite dedicated to Space VLBI as part of the VLBI Space Observatory Programme (VSOP). After the successful launch the satellite was named HALCA (Highly Advanced Laboratory for Communication and Astronomy) – which is an anglicisation of the Japanese word Haruka: far away. HALCA's orbit gave a maximum baseline of 30,000 km so it is a very suitable name.

HALCA was equipped with three wavelength bands: 18 cm, 6 cm and 13 mm, the latter which would have provided the highest VLBI resolutions possible at the time. In check-out phase it was found that the 13-mm system had very high attenuation, probably due to alignment damage during the launch. The other two bands worked perfectly and over its seven-year lifetime HALCA made more than 700 observations of quasars, blazars, masers and pulsars.

In its later years HALCA has been getting arthritic, as two of the four momentum wheels – which keep the pointing constant – have slowly worn out and seized up. Heroic efforts succeeded in recovering attitude control of the satellite after several failures. Before launch, the satellite was expected to have a three to five year life-expectancy, with degradation of the solar panels by cosmic radiation foreseen as the major limitation. With HALCA's final observations made over 6.5 years after launch, the satellite has certainly exceeded expectations.

The last observations were made in October 2003, shortly after which control was lost again. Since then all attempts to restart a third reaction wheel have failed. In September 2004 the decision was taken to down grade the monitoring of HALCA from six to one pass each week. This essentially is acceptance that further efforts at restarting are unlikely to succeed.

The Australian connection to HALCA is implicit in the VLBI baselines formed for southern sources, but also through the close association of Australian researchers: Primarily D Jauncey (ATNF), J Reynolds (ATNF), A Tzioumis (ATNF), S Tingay (JPL/ATNF/Swinburne), S Horuichi (NAOJ/JPL/Swinburne), P McCulloch (Tasmania), J Lovell (ISAS/ATNF), P Edwards (ISAS), and R Dodson (Tasmania/ISAS). The latter three have benefited from the Japan Society for the Promotion of Science fellowships.

A selection of research highlights are:

1. AGN brightness temperatures greater than the inverse-Compton limit (Tingay et al. 2001; Scott et al. 2004);
2. distribution of spot sizes in OH maser sources (Slysh et al 2001);
3. the superluminal quasar 3C345 (Klare et al 2000) and 3C273 (Lobanov & Zensus, 2001);
4. multi-epoch imaging of the quasar 1928+738 (Murphy et al 2003);
5. the M87 jet (Junor et al 2000);
6. the detection of high redshift quasars (e.g., Lobanov et al. 2001); and
7. observations of the Vela pulsar (Gwinn et al. 2000).

A special issue of PASJ is planned to bring together a collection of more results. (And with the proprietary period now having elapsed for all VSOP observations, the data archive is starting to be mined!)

Following the success of the VSOP, a next generation space VLBI mission, currently called VSOP-2, is being planned. For VSOP-2, higher observing frequencies, cooled receivers and increased bandwidths will result in gains in resolution and sensitivity by factors of 10 over the VSOP mission. The possibility of including a rapid slewing capability for the spacecraft is also being pursued, so that observations using the phase-referencing technique will enable the sensitivity to be improved even further. The VSOP-2 proposal will be formally submitted to ISAS in September this year. (A call for proposals last year had to be rescinded after a reassessment of ISAS's long term budget profile.)

HALCA has been the excuse for the purchase of far too many bottles of Very Special Old Pale brandy, and many (but not enough) trips to Sushi bars and Karaoke. It will be missed.

遥か

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Richard Dodson for the VSOP group
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Tim Cornwell joins ATNF

Tim Cornwell

We are pleased to announce that Tim Cornwell has joined ATNF as a senior software scientist in the Science Computing Group. Tim comes from NRAO, Socorro, where he held many different positions, from post-doctoral fellow in the early eighties to Associate Director from 2000 to 2003. He has worked on many aspects of radio astronomy from radio jet observations with the VLA to operations of the VLBA to design of the Millimeter Array (now ALMA). His prime interest lies in the processing of radio synthesis observations to produce scientific results. He has made many key contributions in this area, including self-calibration and mosaicing. He has worked on the development of software packages for processing, including contributing to AIPS and managing the AIPS++ Project from 1995 to 2000. His role at the ATNF will be to contribute to the development of xNTD and SKA. The ATNF and the Australian SKA development projects are fortunate to have the benefit of Tim’s immense experience in radioastronomy.

He and Judi set some sort of record in making an offer on a house within ten days of arriving here. They are now happily resident in Thornleigh and enjoying Sydney immensely. We welcome them both.

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New Bolton fellow

Erik Muller

A big welcome to Erik Muller who started his Bolton Fellowship on 1 April 2005 at the ATNF in Epping. Erik is well-known to many of us, having completed a PhD at the University of Wollongong under the co-supervision of Lister Staveley-Smith. His main thesis topic was the high resolution study of HI and CO in the Magellanic System using the Compact Array, as well as the Parkes and Mopra telescopes.

After completing his PhD in 2003, Erik worked at the Arecibo observatory where he continued his research on the interstellar medium of perturbed systems, star formation and high velocity clouds. Erik also assisted with the commissioning of the Arecibo multibeam receiver, and wrote Arecibo data-reduction pipelines.

Erik is now a full time member of the ATNF astrophysics group and plans to spend a lot of his time on the analysis of the neutral hydrogen and molecular gas in the Magellanic System and other interacting galaxies.

Baerbel Koribalski
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ATNF student symposium

The ATNF has a very successful graduate student program attracting students from around Australia and internationally. The students have the chance to use world-class facilities and have access to a much wider astronomical community. They also have an opportunity to develop public speaking skills by presenting their work at lunchtime meetings and at symposia. One of these is the annual ATNF student symposium.

The ATNF student symposium began in 1998 and allows higher degree students the opportunity to present their research to fellow students and staff. It also provides an excellent opportunity for students to catch up with old friends and to discuss their work with others in similar positions to themselves. There are a number of ways students can present their work:

- Describe the thesis outline (for people just commencing in the current year);
- Discuss the global results;
- Discuss an interesting specific result;
- Present a problem encountered in student research and initiate a discussion with the audience.

This year's symposium was held on 11 May at ATNF headquarters in Sydney. The speakers included Sydney-based students, students from the ACT and Victoria and visitors from Adelaide. The symposium was well attended with ATNF staff, other students and, most pleasing of all, university supervisors. It was very encouraging to see this level of support for the students and it provided a fantastic environment for a number of interesting questions and discussions to occur after many of the presentations.

There were 11 talks ranging from early thesis introductory talks through to talks from those who were close to submitting. They covered a wide variety of topics from a discussion on the current status and future progress of the upgrade of the software correlator for VLBI to the applications of wide-field VLBI observations. There was a presentation on a new type of inexpensive (Styrofoam!) telescope built here at ATNF to be used at the Australian SKA site at Mileura in Western Australia that will allow us to detect HI out to redshifts of 11.5! We also had presentations on millisecond and high magnetic field pulsars, structure of the Magellanic Stream, dwarf galaxies, extragalactic jets and plans to model the interaction between radio plasma and the warm-hot intergalactic gas/medium associated with filamentary galaxy distribution.

We were treated to a lovely feast for our lunch provided by the ladies from the canteen. For this we must thank Sylvia and Barbara from the canteen and also Phil Sharp from the workshop for helping set up the luncheon and serve the food. I also thank Ilana Klamer who co-organised the whole event.

Next year we hope to see many of our inter-state visitors back again as their presence was a great highlight and we look forward to hearing about new results from old and new students.

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Graduate student program

We'd like to welcome the following students into the ATNF co-supervision program:

- Marcella Massardi (SISSA/ISAS) has commenced her project entitled "Observations of the large scale structure of gas in the Universe" with Prof Gianfranco De Zotti (Padua) and Prof Ron Ekers (ATNF). The project is aimed at SZ studies as a tool for investigating the evolution of cosmic structures on different scales.

- Adam Deller (Swinburne) has commenced his project entitled "Software correlation for advanced VLBI, with applications in pulsar and extragalactic astrophysics" with Dr Steven Tingay (Swinburne), Prof Matthew Bailes (Swinburne) and Dr John Reynolds (ATNF).

We also congratulate Brad Warren for the recent successful submission of his ANU PhD thesis "The Nature of High HI Mass-to-Light Ratio Field Galaxies".

Finally, a great Annual Student Symposium happened on 11 May, organised by Ilana Klamer and Katherine Newton-McGee (see page above). A fantastic set of talks was presented by 11 students and was extremely well attended by other students, supervisors and staff. See: *www.atnf.csiro.au/research/conferences/ student_symposia/ASS2005/*

Lister Staveley-Smith
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Graduate Student Convener

Distinguished visitors program

The ATNF has a "Distinguished Visitor" program to facilitate working visits by leading international researchers. The program provides some financial and logistical support for researchers planning to work at the ATNF during visits of no less than one month and up to one year.

Current visitors are Joel Weisberg (Carleton College) and John Storey (University of New South Wales).

Over the next year we are looking forward to visits from Tamara Helfer (University of California, Berkeley), John Lugden (University of California, Berkeley), Michael Kramer (Jodrell Bank), Busaba Kramer (NECTC, Thailand), Juan Uson (NRAO), Mary Putman (University of Michigan), Nissim Kanekar (NRAO), Jayaram Chengalur (NCRA, Pune), Ralf-Juergen Dettmar (Ruhr-University Bochum), Ken Kellerman (NRAO) and Robert Williams (STScI).

Interested visitors should discuss working visits with the Director or an ATNF member of staff.

Naomi McClure-Griffiths on behalf of the DV Committee (Naomi.McClure-Griffiths@csiro.au)

Graduation celebration for Alex Dunning

It was a proud day for Alex Dunning of the ATNF's Engineering Development Group when he graduated with the degree of Bachelor of Science (Applied Physics) from the University of Technology (UTS), Sydney on 2 May 2005. This was the culmination of six years part-time study and his record was also recognised with the "Recommendation for Academic Excellence" – a prize awarded by the Dean. A ceremonial dinner later in the year will recognise this effort.

Alex will continue his studies for a further two years to gain honours through project work at UTS under Dr Geoff Anstis, pursuing research concerning the effect of nano-particles on electron beams.

The attainment of the degree might have been a sufficient challenge for most but Alex simultaneously completed a Diploma in Electrical Technology at TAFE. Additionally he was able to make valuable contributions to receiver design and fabrication. He makes the leap from electromagnetic modelling guru producing radical new designs for receiver ortho-mode transducers to bench technician soldering waveguide flanges with no fuss. All his work reflects a drive for excellence. He has had an impact on the ATNF through his ventures into new paradigms and as a key enabler in helping the receiver group reach its outcomes in both core and non-core business activities.

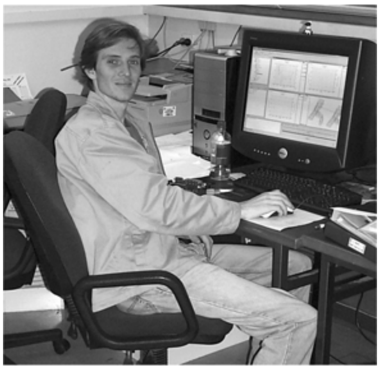

Photo: Graeme Carrad

Alex Dunning

We congratulate him and wish him all the best for future successes.

Graeme Carrad (Graeme.Carrad@csiro.au)

A ceremony for Phil Sharp

A small surprise ceremony happened in the Marsfield canteen at morning tea on 18 May to recognise Phil Sharp's 35 years of working with CSIRO. To acknowledge his birthday the day before, he received a muffin with candle atop and to recognise his contribution to keeping the Radiophysics labs kicking along he was presented with a CSIRO shirt embroidered with:

Photo: Pat Sykes

Phil Sharp with the ceremonial muffin.

"Phil – Looking after RP since 1970"

His extracurricular activities that benefit the Marsfield site are tireless and selfless and hopefully the shirt goes some way to show Phil the appreciation of staff for his efforts.

Graeme Carrad (Graeme.Carrad@csiro.au)

Articles

Cosmological re-ionization experiment

The ATNF has a project in progress to develop a telescope for the detection of signatures of re-ionization in the early universe. The experiment aims to exploit the extremely low RFI environment at the Mileura site in Western Australia. The execution of this difficult objective would be a strategic development of low-frequency astronomy techniques and a pathfinder to doing useful astronomy from Mileura.

After the baryons recombined at redshift $z = 1089$, the kinetic temperature of the neutral gas initially followed the CMB radiation temperature and, therefore, the hydrogen was not detectable in redshifted 21-cm transition. The temperatures decoupled at $z \approx 200$ and, subsequently, the gas is potentially detectable in absorption or emission depending on the neutral fraction in the hydrogen and its spin temperature. The gas would cease to be observable in the 21-cm line once re-ionization was complete at $z \approx 6$. Many low-frequency radio telescopes have been proposed and are being built with the aim of detecting the spectrum of spatial-frequency fluctuations in this redshift window as a probe of structure formation, re-ionization process and thermal history of the gas during these epochs. We have initiated a project to develop capability for sensitive wide-band measurements of the mean spectrum of the sky at VHF frequencies: the aim here is to detect any features in the all-sky spectrum that might arise from the cosmological evolution in the gas.

The project is a developmental effort towards a telescope and receiver, that would view the sky with steradian angular resolution, and would be capable of detecting the few mK spectral features that might be present in the background sky that has a brightness exceeding 1000 K. The Galactic diffuse emissions as well as thermal and non-thermal sources in the sky are believed to have smooth continuum spectra; however, angular structure in the sky brightness may result in spurious spectral features if the antenna response varies across the band. Interference can also be a show stopper, either by directly corrupting the entire band or by generating inter-modulation products across the band. Another key issue is the calibration of the spectral response of the system and the subtraction of additive contributions from within the receiver and from the environment. These considerations have led us along a path that uses frequency-independent antennas, a very simple analogue chain, and a multi-bit digital filter bank. Additionally, we adopt correlation techniques to cancel the additive contributions that may have confusing spectral features. In the Mark-1 system that we are working on, the sky signal is split in a power divider immediately after the antenna and the pair of signals is processed via parallel receiver chains and a correlation spectrometer. The roadmap for the project envisages moving the splitter stage up the signal path.

Photo: Aaron Chippendale

Figure 1: Barry Parsons and Michael McDonald with their creation: the styrofoam structure of the pyramidal antenna. The three-piece pyramid was built in the Marsfield workshop by gluing together precisely cut styrofoam slabs.

We have built a two-arm pyramidal log-spiral antenna to operate over the frequency band 100 – 228 MHz. The antenna was designed to have a structural bandwidth of 20:1 so that the beam pattern would be frequency independent, at the 1% level, over the octave operating band. The support structure is shown in Figure 1 and is a pyramid made using a grade of styrofoam. The structure was designed to be made in three parts that fit together to form the pyramid. Each of these parts is a box frame formed by gluing precision cut slabs of the foam. Ideally we would like to make the pyramidal support structure of materials

Photo: Rob Power

Figure 2: The finished antenna was taken out to a clearing on the Marsfield site for measurements: Ron Ekers, Ravi Subrahmanyan, Peter Shaver and Aaron Chippendale.

that are 'invisible' at the observing frequencies: we measured the dielectric constant and loss tangents of the foam material and the glue and paint by hanging samples in front of the feed cone of one antenna of the Compact Array while the interferometers observed a calibrator source. The measurements showed that the contributions from the structural materials should be insignificant. Figure 2 shows the completed antenna after the foam structure was painted and a pair of wire arms was put on. The wires may be easily removed and replaced at a remote site with a different pitch angle or with four-arm log-spirals.

The analogue chains have separate couplers for adding calibration noise into the signal path, low-noise amplifiers, filters that limit the band to the range 114 – 228 MHz for the Mark-1 system, attenuators and further amplifier stages. The 8-bit samplers lead to poly-phase filter banks and cross multipliers implemented on a Berkeley S5 spectrometer board: we obtained the spectrometer hardware thanks to Dan Werthimer and his group at Berkeley.

The lively discussions that explored different concepts have been an intellectually stimulating experience for all those who participated; the wealth of ideas offered from within and beyond the ATNF has been very thought-provoking and motivating. Significant changes in the system design and project plan continued throughout the last year; only the pouring of concrete could stop that. We now have all the bits and pieces on hand and, as seen in Figure 3, are at the critical stage of system integration and debugging. The antenna will be observing at the Mileura station in Western Australia within months and we look forward to interesting times ahead exploring unknown territory while attempting this exceedingly difficult experiment in the outback. This Mark-1 system is our first step towards the re-ionization epoch.

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Photo: Rob Power

Figure 3: Aaron and Ravi looking at first tests of the performance.

Continued from page 1

Radio emission from the 27 December 2004 giant flare from SGR 1806-20

detection was important in understanding the physical mechanism behind these giant bursts since the magnetar model (among others) predicts the expulsion of relativistic particles from the surface of the NS during these events. Unfortunately, this radio source was not detectable for a long enough period of time to measure the properties of the material driving the nebula (e.g. its mass and energy) precisely enough to compare with the theoretical predictions.

On 27 December 2004, SGR 1806-20 emitted a giant flare (GF) which was by far the brightest such burst from a magnetar, and in fact was the brightest event ever detected in the history of γ-ray astronomy. The burst was so bright that it saturated every γ-ray detector in space (Palmer et al. 2005; Hurley et al. 2005; Mereghetti et al. 2005; Israel et al. 2005), save for a small γ-ray detector on a Russian spacecraft designed to study the solar wind which was in the Earth's shadow at the time of the events and detected γ-rays which were reflected by the Moon (Mazets et al. 2005). Seven days after the GF, SGR 1806-20 was observed with the VLA which detected (Cameron & Kulkarni 2005; Gaensler et al. 2005a) not a faint radio source but an extremely bright one – over 170 mJy at 1.4 GHz (Gaensler et al. 2005b; Cameron et al. 2005). As a result, a worldwide radio monitoring campaign of this source began which incorporated a large number of radio telescopes – including the Australia Telescope Compact Array (ATCA), whose broadband receivers allowed us to monitor the source at five frequencies (1.4, 2.4, 4.8, 6.1, and 8.5 GHz, with 2.4 and 6.1 GHz only achievable with the ATCA) in a single observation, invaluable for the success of this project – the results of which are shown in Figure 1. Thanks to the dense temporal coverage of twice-a-week observations with both the VLA and ATCA for the first two months after the flare, we have identified the following regimes in the light curve:

- An initial, relatively flat decay in flux ($S \propto t^{\delta}$) with a variable decay rate across the frequencies e.g. at 1.4 GHz, $\delta = -1.6 \pm 0.2$ while at 8.5 GHz, $\delta = -2.2 \pm 0.2$ (Gaensler et al. 2005b).

- Around nine days after the GF, there was a break in the light curve at all six observed frequencies in which the decay rate steepened to $\delta \sim -2.7$ (Gaensler et al. 2005b; Cameron et al. 2005). As reported in Gaensler et al. (2005b), there is no significant change in δ across the observed frequencies.

- Around 25 days after the GF, the source *brightened* for roughly 3 – 5 days in all five of the observed frequencies. Thanks to fortuitous timing and spacing of the ATCA monitoring observations, we were able to measure both the rise and fall of this "bump" in the lightcurve (Gelfand et al. 2005).

- After the "bump", the flux has decreased as $S \propto t^{-1}$ in all five frequency bands. Due to source confusion, we have not been able (yet) to get 1.4 and 2.4-GHz fluxes at some epochs so the light curve is not as well sampled at these frequencies. However, we see no evidence in the data that we have already reduced that the source is behaving any differently at these frequencies than it is at 4.8 and 8.5 GHz which are somewhat better sampled.

With these results, we have been able to explain the radio source in terms of the "magnetar" model. In this model, the GF is caused by magnetic reconnection triggered by a disturbance on the crust of the NS. This magnetic reconnection creates a lot of γ-rays, most of which are ejected during 0.5 sec "hard spike" seen in the γ-ray light curve (e.g. Palmer et al. 2005). During this initial "hard spike", matter will be ablated off the surface of the NS and stream into the surroundings (Thompson & Duncan 1995). Since the escape velocity of a NS is ~ 0.4c, this outflow will at the very least be mildly relativistic and will generate shocks that produce the synchrotron radiation seen in the radio – creating the radio synchrotron nebula detected after the 27 December GF.

Using the radio light curve, we can trace the evolution of this synchrotron nebula as well as determine its initial properties. We believe that the initial flat-decay radio flux described above was the result of a collision between these particles and a pre-existing shell around the SGR, either from a quiescent particle wind generated by its spin-down or from highly relativistic electrons generated during the GF or in the particle outflow itself. This collision probably happened before the first VLA observation, but due to light-travel effects we observed this collision for several days (Granot et al. 2005). As a result of this collision, most of the ejected material was swept-up into a thin shell which then continued expanding. Assuming the shell maintained a constant thickness as it expanded, the magnetic field inside the source should have dropped precipitously during this phase, which, coupled with adiabatic cooling of the electrons leads to the steep decay in the light curve seen between 9 and 25 days after the GF (Gaensler et al. 2005b; Granot et al. 2005). However, as it expanded, the ejecta from the surface of the NS swept up and shocked the surrounding ISM. The shocked ISM material formed a thin shell around the ejecta material, similar to that seen in supernova remnants. As more and more material was swept-up, the layer of shocked ISM got brighter until it outshone the cold ejecta. At this point the radio source re-brightened, as was observed 25 days after the flare. By modeling the properties of the re-brightening, we are able to estimate that the ejecta had an initial mass of ~ 10^{24} – 10^{25} gm and an initial kinetic energy of ~ 10^{44} – 10^{45} ergs (Gelfand et al. 2005). While the exact numbers depend on the shock physics, the morphology of the material ejected during the GF and the properties of the surrounding ambient material, this mass and energy is consistent with that predicted by the magnetar model. At the time of re-brightening, it was also expected that the expansion velocity of the source would decrease significantly – as observed by the VLA (Taylor et al. 2005) and confirmed by a 12-hr 9.0-GHz ATCA observation on 7 April. After this re-brightening, the source was expected to behave like a supernova remnant in the Sedov-Taylor phase of its evolution (Gelfand et al. 2005), which explains the t^{-1} decay in the radio flux.

The above description is supported by VLA observations which have allowed us to precisely measure the source's size and position (Gaensler et al. 2005b; Cameron et al. 2005; Taylor et al. 2005). As mentioned above and shown in Figure 2, we have determined that the expansion velocity of the radio nebula significantly decreased at the same time of the observed "re-brightening", from ~ 4.5 mas/day to less than 2.5 mas/day (Taylor et al. 2005). Reduction of these VLA observations has also enabled us to determine that the radio source is significantly elongated, with an axial ratio of ~ 0.6 (Taylor et al. 2005). We have also measured a proper motion of the radio source – it appears to be moving along its major axis with an average velocity of ~ 3.0 mas/day, roughly half of its growth rate. As a result, we believed that mass outflow from the NS was predominantly one-sided (Taylor et al. 2005) – consistent with the matter being ejected during the initial spike seen in the γ-rays. Less than 20 days after the GF, polarized radio emission was detected from the radio source (Gaensler et al. 2005b; Cameron et al. 2005), with the position angle of the linear polarization roughly perpendicular to the major axis – consistent with a shock-produced magnetic field (Taylor et al. 2005).

With further observations, we hope to understand better the morphology and size evolution of the source – which is important in understanding the ejection mechanism of the material off the NS, as well as the source's behavior during the Sedov-Taylor phase of its evolution and its eventual transition into its radiative phase. The 27 December GF is a once-in-a-human-lifetime event, and possibly a once in a NS's lifetime event as well, and presents a unique opportunity to study the properties of magnetars and the evolution of explosions in the ISM.

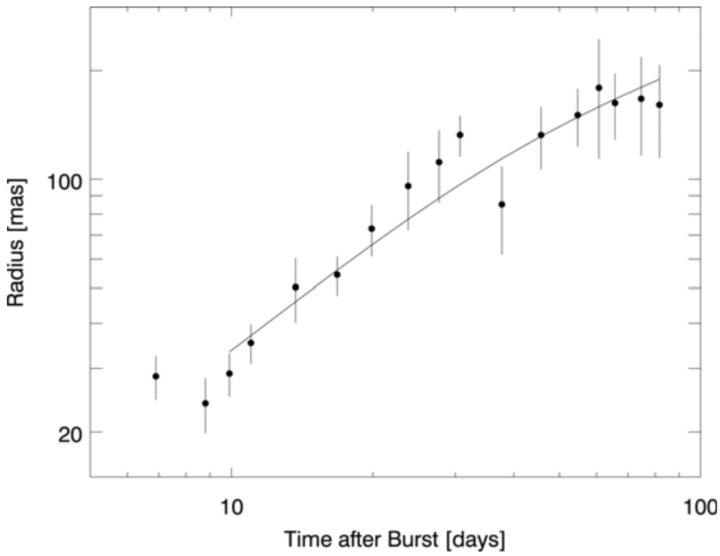

Figure 2: The solid line is a fit of an expanding shell model as described in Gelfand et al. (2005). This plot is Figure 2 in Taylor et al. (2005).

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Joseph Gelfand (Harvard-Smithsonian Center for Astrophysics), Chryssa Kouveliotou (NASA GSFC), Bryan Gaensler (Harvard-Smithsonian Center for Astrophysics), Yuri Lyubarsky (Ben Gurion University), Greg Taylor (KIPAC/Stanford University/NRAO), David Eichler (Ben Gurion University), Yoni Granot (KIPAC/Stanford University), Katherine Newton-McGee (U. Sydney/ ATNF), Enrico Ramirez-Ruiz (IAS), Rob Fender (U. Southampton) and Ralph Wijers (U. Amsterdam)

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Regular items

ATNF Outreach

ATNF teacher workshops

One of the strategic objectives of the ATNF is to conduct an effective outreach and education program. Astronomy generates a high level of public interest and is well-suited to encouraging the next generation of students towards a science-based career. The ATNF education program provides educational resources for astronomy, in particular for Australian high schools. These include the ATNF outreach and education website at
http://outreach.atnf.csiro.au
and a range of workshops for high school teachers.

Two successful workshops for teachers were held recently. *Astrophysics for Physics Teachers* was a one-day workshop for teachers of HSC Physics held at the Marsfield site on Saturday, 5 March. 21 teachers participated and heard talks on cosmology and stellar evolution from ATNF and AAO staff. They also learned some innovative and practical ways to present the concepts in class and went back to their schools with a wealth of resources to use.

The second *Astronomy from the Ground Up!* workshop was held at Parkes on 13 – 15 May in gloriously sunny weather. 24 teachers and two staff members from the Parkes Visitors Centre attended. The workshop included talks on a range of astronomical topics, explored the latest in astronomy education resources and activities. Participants also learnt how to run a viewing night and find their way around the night sky. Ample time was allowed for discussions with professional scientists and colleagues. Highlights included a walk on the surface of the Dish, a “hayride” back down and a magnificent “Dinner by the Dish” at the Parkes *Dish Cafe*.

The ATNF together with the Western Australian Office of Science and Innovation, Scitech in Perth and the Science Teachers’ Association of WA provided funds for two scholarships to enable teachers to come from Western Australia for the workshop. The two teachers awarded scholarships were Darren Hamley from Willeton Senior High School and Lance Taylor from Rockingham Senior High School in Perth. Both gave interesting talks to the other teachers about teaching astronomy in the classroom.

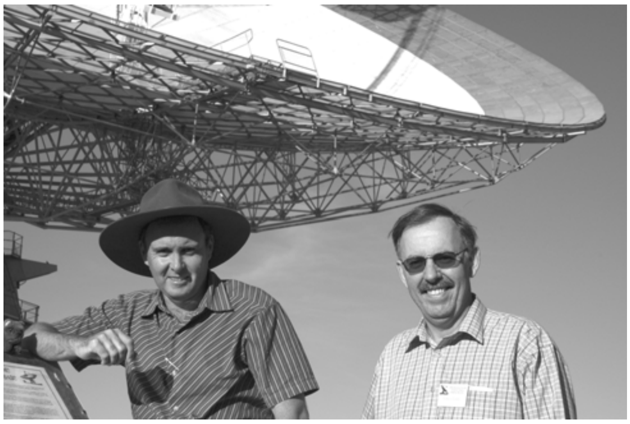
Photo: Robert Hollow

Figure 1: Winners of the WA Science Teacher Scholarships: Darren Hamley (left) and Lance Taylor (right) at Parkes.

Narrabri Visitors Centre

Plans for the development of the Visitors Centre at Narrabri are progressing well. Designs for a range of new displays, including interpretive panels, sculptures and other exhibits have now been completed by the company *Convergence Design*, in consultation with ATNF staff. The new displays will be located in the grounds around the Visitors Centre building and will provide visitors with a wealth of information about the Compact Array, the Narrabri site, the ATNF, CSIRO and astronomy. Several sculptures will be installed to show visitors three-dimensional models of the Magellanic Clouds, radio galaxies and the expanding universe. These, together with interpretive panels, will lead visitors on a tour from our Galaxy to the distant universe. Other exhibits will show the more technical side of radio astronomy with information provided about radio waves and how radio telescopes work.

The construction work for the Visitors Centre is expected to begin in June and the on-site installation to be completed by early September.

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Compact Array and Mopra report

3 mm developments

Since the end of the 2004 millimetre season, substantial progress has been made on improving the overall functionality of the 3-mm system.

As mentioned in the last newsletter, a problem of low gain on antenna CA01 has been resolved. During March, axial and lateral adjustments have been made to optimise the subreflector position on a number of antennas. Partly driven by work for NASA, the so-called "second derivative" problem of the phase rotators (a problem that has been known for many years) has at last been properly understood and resolved. Subsequent measurements of the local oscillator stability show that it is excellent (less than 3 degrees rms phase noise at 86 GHz). With all five antennas now showing good gain, reference pointing is now much more robust.

On the hardware side, a new 3-mm low-noise amplifier was installed into one antenna (CA04 channel B). This is now by far the best receiver in the system, with system temperatures as low as 170K. Amplifiers in the millimetre conversion chain have also been replaced. This has helped to make the power across the system more uniform, and to make the system temperature measurement scheme (paddle calibration) more robust.

Figure 1 (with thanks to Tony Wong) shows the system sensitivity of the 3-mm receivers across the band. As can be seen, the best sensitivity is at 93 – 95 GHz.

On the operational side, the flux densities of about 120 "bright" 3-mm calibrators were re-measured in May. These measurements have been included within the Compact Array calibrator web search engine. During the 2005 season the flux density of the calibrators 1921-293 and 1253-055 will be measured, on a monthly basis, using Mars and Uranus as primary flux standards. As a consequence it will be possible for a number of observing projects to use 1921-293 and 1253-055 as flux standards rather than the planets.

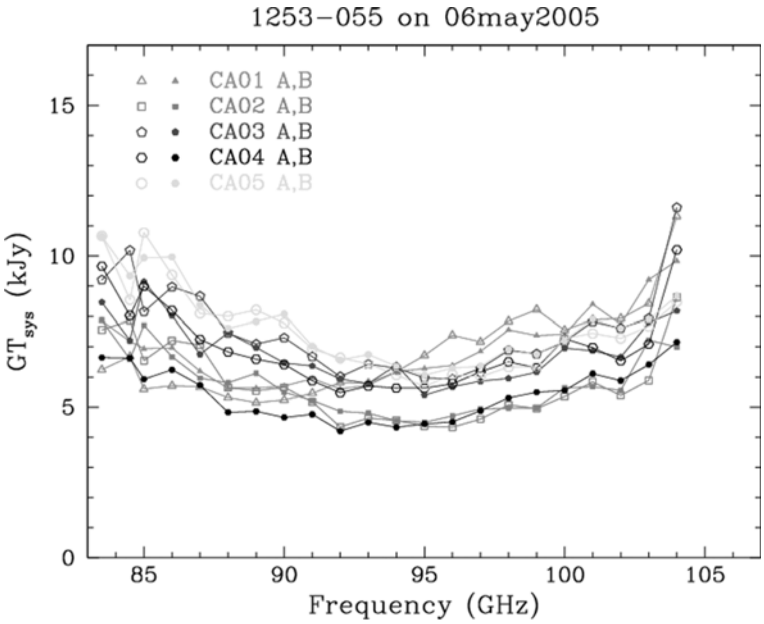

Figure 1: Compact Array system sensitivity at 3 mm.

During February and March, the seeing monitor was modified to improve the unit's cooling. This is back in service, with the output also available on the web.

There are still a number of avenues being worked on to improve the utility of the 3-mm systems. These include better understanding of some instrumental phase errors, installing an opacity meter, improved pointing models, understanding gain/elevation effects (these may have a temperature dependence), as well as enhancements to the on-line and off-line software.

Other developments

The Compact Array Linux observing system is largely complete and is now in a "friendly user" testing phase. It is anticipated that the Observatory will switch from the VAX systems to this in July or August. If you are at Narrabri, we invite you to volunteer to try the new system.

Installation of the second 16-MHz filter system is on track to be ready for use during July.

Operations

Usage statistics for the period 1 January – 1 June are given in Figure 2. In addition to normal scheduled astronomy time, a portion of Compact Array time is left as "Director's Time" in the final schedule. This is

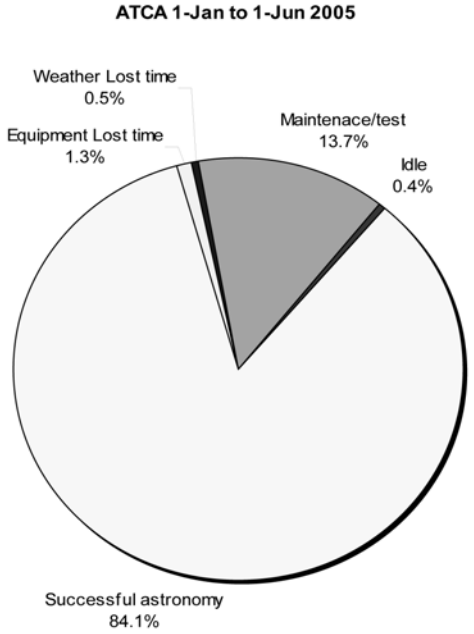

Figure 2: Usage statistics for the Compact Array to 1 June 2005.

a combination of small gaps that could not be reasonably scheduled and some longer periods that are specifically set aside to give some flexibility with NAPAs, ToOs and replacement time requests. In the five months to 1 June, 5.5% of array time was marked as Director's Time. The breakdown of usage of this time is given in Figure 3. C007 is a long-running program to monitor Compact Array calibrators; this is run as a filler project when there are no other requests.

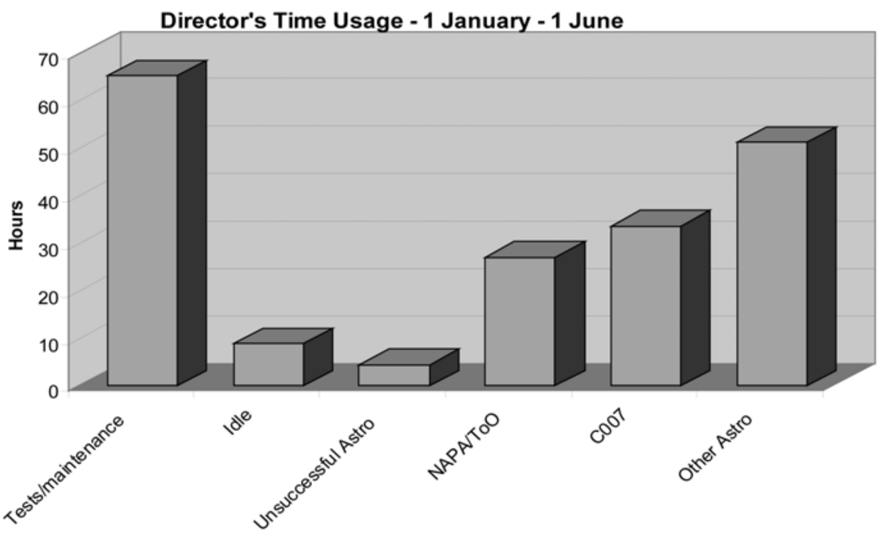

Figure 3: Director's time usage for the Compact Array to 1 June 2005.

Building work

Funding has been approved for a major refurbishment of the Narrabri Control Building. An architectural firm is currently producing initial designs for discussion. The indicative plan is for detailed designs to be started in July, tender documents to be distributed late in 2005 for construction, and for construction to start in mid-2006.

At the same time, funding appears likely to upgrade the Narrabri Lodge. Planning for this is also at an initial design phase. The work on this would be anticipated to start late in 2005.

Mopra

Mopra remains an area of significant development. During 2005 we expect to replace the front-end, the back-end, the control software and the network link.

Porting of the Mopra observing system to a LINUX environment is progressing well, thanks to the efforts of Mike Kesteven, Euan Troup and Mark Calabretta. However, there are still a few issues that need to be addressed.

Replacing the Mopra 3-mm SIS receiver with a "Compact Array-style" MMIC receiver is a part of the MNRF-1997 program. Following the successful installation of the 3-mm systems at the Compact Array in 2004, it was intended that the Mopra receiver would be ready for the 2005 season. Unfortunately this has been delayed until September 2005 and the SIS system will be used until then.

Work on the new MMIC system for Mopra is proceeding well. This receiver will benefit from several improvements in the design over the Compact Array receivers installed in September 2004. In particular, broader-band low noise amplifiers are being used, and the local oscillator design avoids some issues apparent with the Compact Array 3-mm receivers. Additionally radio frequency gain equalisation is being included in the signal path to assist in sideband separation. The receiver is expected to have good performance between 85 and 115 GHz. Because tuning is not required for the receiver, there will be significant time savings for observers in configuring the receiver. Additionally one of the polarisations will not need to be sacrificed to observe SiO for pointing. The system temperature, however, is expected to be poorer than the existing SIS system.

A complement to the new receiver is the new digital filterbank bankend, called MOPS. Ultimately MOPS will consist of four 2-GHz segments that can be configured to observe several spectral lines simultaneously within an 8-GHz window. This, combined with Mopra's on-the-fly mapping capability, will make Mopra an excellent survey instrument. It is hoped that initially one 2-GHz segment segment will be available for installation in September. Only one zoom mode, at 64-MHz bandwidth, is likely in the first instance. It is intended that all segments will be available for the 2006 millimetre-season. As an interim measure, the so-called POCS system (a proof of concept system for MOPS) will be installed at Mopra in July to support some projects.

Another development project at Mopra has been to implement remote operation. This development has focused on gaining robust and reliable primary monitoring and control of the Mopra systems. Work on this is now largely complete. However remote operation of Mopra will not be possible until the MMIC system is installed (tuning of the SIS system requires the observer to be at Mopra) and a faster network link is available. Both of these should be achieved by September.

Mopra induction weekend

The annual Mopra Induction Weekend was held on 27 – 29 May. This workshop is devoted to introducing people to the science and techniques of 3-mm astronomy, along with practical information on how to make best use of the Mopra telescope. The weekend included a series of talks, tutorials and practical sessions, plus a dinner at Skywatch Observatory. Participants came from Bonn, Swinburne, Macquarie University, UNSW and ATNF. In total, 24 people attended the weekend. Thanks to all those who made it a very successful weekend.

Finally, those who observe at Mopra will notice that it has already undergone a minor facelift, with new carpets and paint, and a rationalisation of the Mopra office.

Bob Sault
Officer-in-Charge, Narrabri Observatory
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Photo: Bob Sault

Figure 4: Juergen Ott giving a tutorial at the Mopra workshop.

Parkes report

Steering Committee visit

The Observatory hosted the ATNF Steering Committee (ATSC) over 14 – 15 April, using the Quarters facilities. A very enjoyable dinner for ATSC members and visitors was provided on the night of the 14th by the *Dish Cafe*. The visit featured the obligatory "hayride" for the Committee, and a visit to the focus cabin for the more enthusiastic, including new ATSC members Brett Biddington and Matthew Colless, along with the illustrious Bob Frater (making his first return to the focus cabin in many years). Many thanks to all staff for making the visit such a success.

Operations

Telescope operations this year have continued to be largely trouble free, with less than 1% of time lost to equipment faults in the year to date. Lost time due to wind is currently at 2.5% as the usual calmer conditions typical of the middle of the year prevail. A recent intermittent problem with the focus-cabin receiver translator caused several hours' lost time and several sleepless nights for technical staff. The fault was eventually identified as leakage to ground in a filtered connector — part of the system that had not been touched in seven years.

Receivers

Construction of the new seven-beam "methanol multibeam" receiver is proceeding on schedule for commissioning in October this year and is advertised as available for general observing from January 2006. Technical specifications are summarised in the Parkes Users Guide. The receiver will be commissioned with a single-frequency LO system. A second LO chain will be added as resources permit over the following months.

As has been flagged for some time, a second-phase refurbishment of the 20-cm multibeam receiver is being planned, for some time in the next six to 12 months. The main reason for the refurbishment is to replace all remaining original low noise amplifiers (LNAs), several of which are exhibiting instabilities that are proving deleterious to pulsar searching and, to a lesser extent, spectral-line observing (this list now includes channels 11A, 11B ,12B and 13B). Any other maintenance issues of a pressing nature that come to light once the package is disassembled will also be addressed. An upgrade of the cryogenic refrigerators is also being contemplated, subject to the results of further tests.

It is expected that the refurbishment will take approximately three to four months. The refurbishment will be scheduled with user requirements and demands foremost in mind. First thoughts were to begin the work in late 2005, but this could have a serious impact on some existing long-term projects. Undertaking the work towards the end of the 2005OCT Semester may be a better option.

A project concept document has been submitted for a new 12-mm receiver package for Parkes. The new package will employ the same LNAs and orthomode transducers as the Compact Array 12-mm systems. A possible option is to build the receiver as a dual-horn system to double its efficiency for position-switching observations; however this increases the complexity, cost and construction time. With the newly-designed and manufactured feed illuminating the full 54-m high-performance aperture at Parkes the new system should deliver approximately 4 dB of extra sensitivity over the old system.

Owing to the projected high demand in the upcoming semester for both of the large multibeam receivers (20-cm multibeam and the methanol multibeam), a study is being made of the feasibility of allowing the methanol multibeam to be mounted in either position on the receiver translator. If feasible, this option will give greater flexibility in scheduling observations with both multibeam receivers in the same semester. Such flexibility would come at some cost in the availability of the 10/50-cm receiver and other packages, but overall should allow a better match of the schedule to the scientific merits of the proposal pool.

Backends

Modifications to the conversion system were completed in May allowing the full 1-GHz bandwidth of the 10-cm receiver to be exploited. The 1-GHz bandpass sampled by the wideband correlator is now flat to within 3 – 4 dB across 900 MHz (2650 – 3550 MHz). At present the modifications have been made

The new bus is on the right and the old bus is on the left, with the dish in the background.

only to the first half of the conversion system — modified modules for the second frequency chain are under construction.

A problem with the wideband correlator (WBC) samplers was found and rectified in May. This problem is believed to have been exacerbating the "residual ripple" problem in some WBC observations. Subsequent tests have shown a distinct improvement.

Construction of the prototype of the Digital Filterbank (DFB) is close to complete and installation is scheduled for the second half of June. The fully-functional DFB is expected to be operational late this year.

Brief specifications of the prototype and final DFBs are given in the Parkes User Guide, available through the Parkes home page under "Documentation".

Site changes

The upgrade of the worst section of the 6-km road to the site started in November was completed somewhat behind schedule in April, owing partly to delays with rain and problems in sourcing of gravel. The upgraded section has vastly improved the overall quality of the road. The upgrade was jointly funded by CSIRO and the Parkes Shire Council, with the Council carrying out the work.

Work progresses on the new kitchen at the quarters, with construction now complete and fitting-out starting in earnest.

A new shed has been erected on site adjacent to the existing workshop and carpenter's shop. The new shed will serve a number of functions including as a workshop for welding, grinding and cleaning and other activities which are not wholly compatible with the precise machining and milling that is carried on the main workshop. The shed will also garage site vehicles, and provide covered storage for the many raw materials that presently have to sit outside.

The Observatory has a new bus which arrived on site on Monday, 6 June.

Broadband links

The prospect of a new broadband (> 1Gb/s) data link to the Observatory has taken a major step forward with the letting of a contract by AARNet to run the optical fibre connection from the Observatory to their backbone fibre, west of the Newell Highway. The contractors expect to finish laying and terminating the fibre tails in early July. The Observatory is providing cable pits and conduit for the last 100 m from the property boundary to the tower.

Visitors Centre

A new program for the 3-D theatre featuring a 3-D "virtual tour" through the telescope is currently in final production at the Swinburne University of Technology. Pre-release screenings at the Visitors Centre have generated a lot of positive feedback and all are keenly awaiting arrival of the finished product. Thanks go the Matthew Bailes and his team at Swinburn University for turning this long-awaited dream into reality (or a virtual reality at any rate).

On Sunday 24 April of the Anzac weekend, the Observatory staged a "Twilight Concert at the Dish". A sound stage was erected in the paddock adjacent to the Visitors Centre and ticket holders were treated to a memorable and varied program from students of the Conservatorium of Music. The *Dish Cafe* catered for the event, which also showcased the products of the local organic wine producer, Rosnay Wines. All of the 200 tickets were snapped up and the feedback has been uniformly enthusiastic. Plans for a similar event in the near future are already being drawn up.

The Visitors Centre is the venue for a monthly meeting of the Central West Astronomical Society. This society was founded in 2002 and aims to foster and promote astronomy awareness in the Central West of NSW. In addition to the regular monthly meetings, the society hosts dark-sky viewing nights at a site in Cookamidgera, about 10 km south of Parkes.

This year the Society continued to attract a wide range of guest speakers to its monthly meetings. They included Colin Bembrick (noted amateur), Alan Dyer (Canadian Sky and Telescope magazine editor), John Dobson (astronomy legend), Dr John O'Byrne (Sydney University first-year Physics Director) and Prof Joel Weisberg (Carleton College). For more information on the CWAS and its activities, see the following URL: *www.cwas.org.au/*.

The Society's annual AstroFest will be held throughout the month of July. A feature of this astronomy festival is the "David Malin Awards" astrophotography exhibition and competition. Astrophotographs taken by amateurs from throughout Australia will be exhibited in the Observatory's Visitors Centre for the entire month. Last year over 14,000 people viewed the exhibition. Inspired by this success, the exhibition will this year tour the country to selected venues beginning with Sydney Observatory in August.

The AstroFest's two-day conference will be held on the weekend of the 16 – 17 July. A stellar array of speakers is lined up. Two of the highlights of the conference will be the "John Bolton Lecture" on Saturday and the Grote Reber Memorial lecture on Sunday. The AstroFest is open to anybody with an interest in astronomy. For more information on the CWAS AstroFest and the "David Malin Awards" see: *www.parkes.atnf.csiro.au/events/astrofest/*.

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Time assignment information

Duty astronomers

Duty astronomers at the Compact Array are rostered from ATNF staff and students to provide support to observers at Narrabri for periods of one week at a time. The duty astronomers are required to assist observers prepare observing schedules, help set up the Compact Array at the start of an observing run, diagnose and attempt to solve problems that arise in the course of the observations and help observers with the initial analysis of their data.

Following input from the user community some changes have recently been made to the duty-astronomer system with the aim of improving the reliability of the support provided to observers. Since 1 April 2005 the ATNF has reinforced the requirement that duty astronomers are expected to arrive at the observatory before the start of their rostered period. Inexperienced DAs receive a detailed induction during this time from a member of the telescope staff. Experienced non-ATNF astronomers may serve as DA, but only with the prior approval of the ATNF Director. The full ATNF Duty astronomer policy is available on the web at:

www.narrabri.atnf.csiro.au/observing/support/da_information.html.

Remote observing at the Compact Array

Astronomers who are successful in being granted time on the Compact Array are expected to operate the array for their own observations. In most cases, observers are present at Narrabri and operate the array from the on-site control room. It is also possible for experienced observers to operate the Array from remote locations without visiting the Observatory. To help astronomers stay up-to-date with developments at the Compact Array, remote observing is only granted to astronomers who have observed with the array in person at Narrabri within the previous 12 months.

Following the changes to the Duty-astronomer system, a previous requirement, that overseas observers should have provided duty astronomer support, is no longer required. Full information on the conditions for remote observing is available at:

www.narrabri.atnf.csiro.au/observing/remote_conditions.html.

Director's time

Each semester approximately 5 – 10% of time is initially unallocated at the Parkes and Narrabri Observatories and this is designated as Director's time. This time arises from short gaps between scheduled observations and from some longer slots that are set aside for more strategic use such as for NAPA observations.

The Director's time is administered by the officers-in-charge at the Observatories. Observers who wish to apply for Director's time should initially send an email to Bob Sault (for Narrabri) or John Reynolds (for Parkes) with a brief justification for the time requested.

In general Director's time is allocated following a set of priorities with a higher priority given to duty astronomers and other astronomers present on the site than to requests for remote observing. Further information is given on the web page:

www.atnf.csiro.au/observing/directors_time.html.

Tidbinbilla information

From 18 July 2005 until January 2006, the 70-m antenna will undergo maintenance on the azimuth bearing and the antenna controller hardware will be upgraded. No observations will be possible during this time. Tidbinbilla proposals submitted for the 2005APRS deadline will remain active for 18 months rather than the usual 12 months to compensate for this.

The upgrade of the 12-mm system from single to dual channels is progressing well. Installation and testing will be carried out during the 70-m downtime and it is expected that dual polarisation observations will be possible when it returns to service in January.

A new web-based sensitivity calculator is now available to help in proposal preparation. It can be found on the Tidbinbilla page:

www.atnf.csiro.au/observers/tidbinbilla.

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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 *(Christine.VanDerLeeuw@csiro.au)*.

This list includes published refereed articles and conference papers, including ATNF data, compiled since the February 2005 newsletter. Papers which include one or more ATNF staff are indicated by an asterisk.

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