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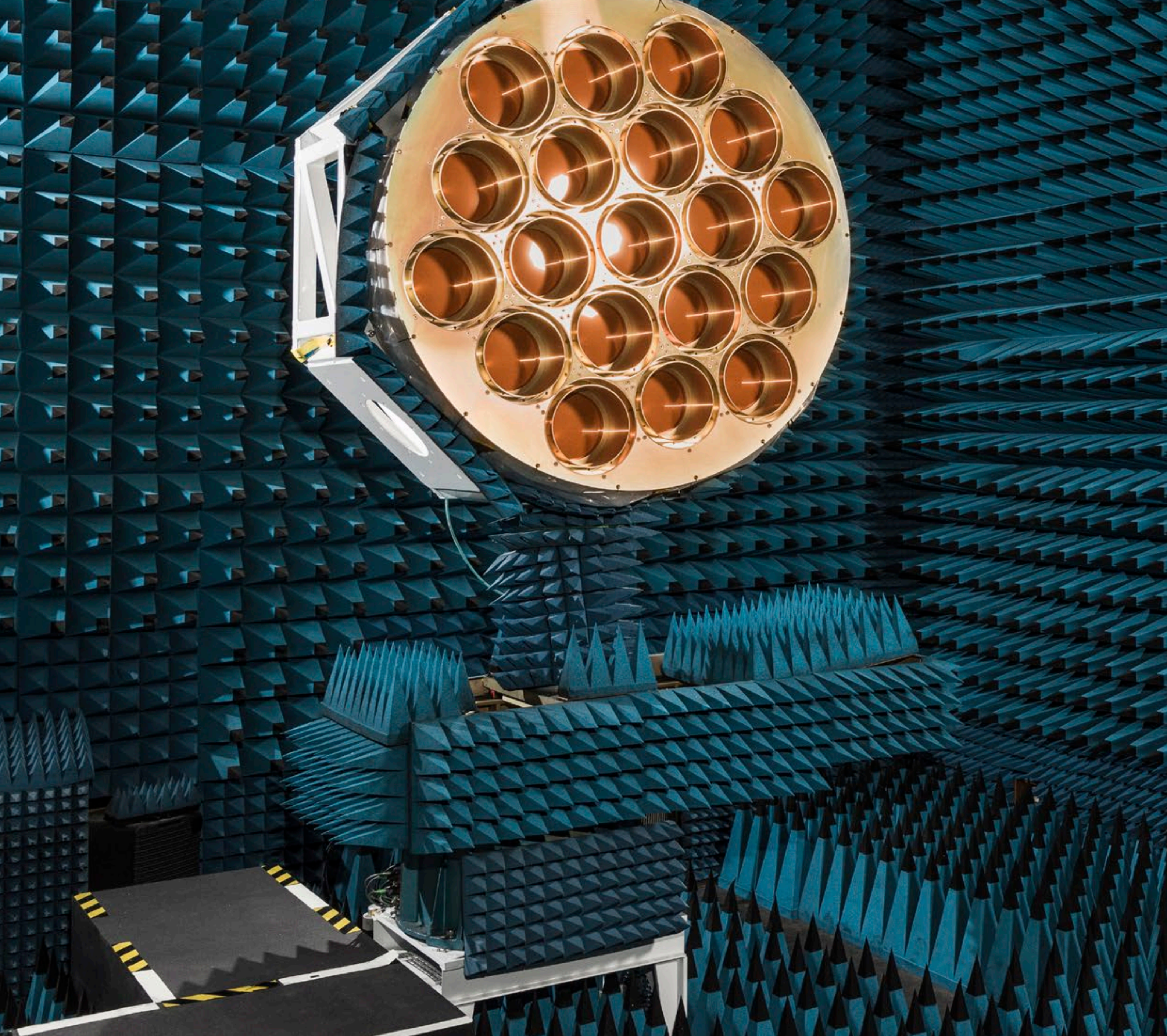
# CSIRO Australia Telescope National Facility

Annual Report
2016



CSIRO Australia Telescope National Facility
Annual Report 2016

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This is the report of the CSIRO Australia Telescope National Facility for the calendar year 2016, approved by the Australia Telescope Steering Committee.

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Cover image: the 19-beam receiver designed and built by the ATNF for China's FAST radio telescope, under test in CSIRO's antenna range at Marsfield, Sydney. Credit: Wheeler Studios

Inner cover image: students from the Pia Wadjarri Remote Community School on a visit to the Murchison Radio-astronomy Observatory. Credit: Rob Hollow

# Contents

# Chair's report

**Dr Susan Barrell**
**Chair, ATNF Steering Committee**
**Credit: Bureau of Meteorology**

The Australia Telescope National Facility (ATNF) continued through 2016 to deliver high-quality science and technology outcomes in support of CSIRO's strategic objectives and contributed strongly to national and international science achievements. The Steering Committee acknowledged the leadership that both Dr Lewis Ball, the departing Director, and Dr Douglas Bock, the new Director, have brought to sustain these achievements, and welcomes the energy and direction that Douglas brings to guide the facility into the SKA era.

The Steering Committee continued to provide high-level advice to guide the strategic directions, performance and allocation of observing resources for the facility. The Committee convened twice through the year and engaged in ongoing consultations as required. The Committee's advice to the Director and the CSIRO Board was focused mainly on three key areas: the Square Kilometre Array (SKA); operations and funding of the ATNF; and technology development.

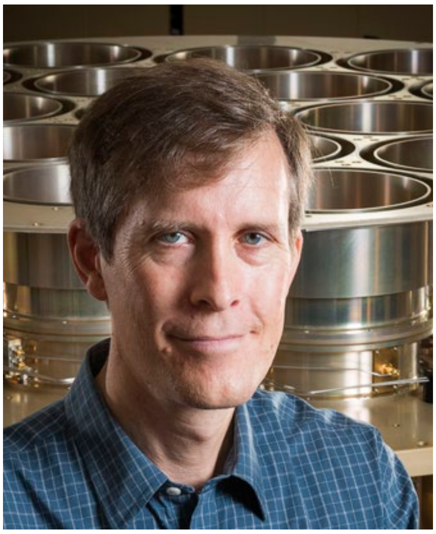
The Committee considered that CSIRO has an essential role in leading and enabling the SKA and on building a widely supported SKA strategy for Australia. It recommended that CASS, as the national radio astronomy observatory, should place increasing emphasis on the SKA, both through a technology program focused on SKA technologies and construction and through seeking roles as SKA Operator and Site Entity for Australia.

The ATNF should build on and strengthen its connections with the Australian and international astronomy communities, and take a leading role in developing an inclusive and nationally collaborative structure for an Australian Regional SKA Centre that provides data services and user support for Australia and the Asia-Pacific region. It should also take a central coordinating role in the development of both a nationally supported science and engineering strategy and a cohesive and well-informed science community for the SKA in Australia.

The status of the ATNF under current research funding challenges, as a true national facility being free to the end user at the point of use, and the ongoing need to consider external funding options, occupied considerable Committee discussion. The Committee recommended a multi-faceted approach to external funding, such as offering telescope time for sale; obtaining external funding to support use of the Murchison Radio-astronomy Observatory (MRO) by instruments other than the Australian SKA Pathfinder (ASKAP), including for the SKA Site Entity role; and identifying new models for funding individual telescopes, such as using the Parkes telescope as an educational facility. Consultation with the broader astronomical community and development of transition strategies supported through bridging funding would be essential, especially to ensure that PhD students are not disadvantaged. To inform the consultation and consideration of options, the Committee also recommended an assessment of the benefit attained through Australian-based astronomers' access to overseas facilities versus international users' access to Australian facilities.

The Committee recognised that a vibrant technology-development program is essential to ensure a world-class capability in radio astronomy in the SKA era and to broaden the impact of ATNF technology. To achieve that, the Committee recommended that CSIRO invest at a significant level to maintain and develop long-term capability for radio-astronomy instrumentation; maintain a pipeline of projects with a mix of SKA and other telescopes to ensure sustainable revenue, continuity and scale; and engage with partners to maximise the impact of radio-astronomy technology and capture innovations from outside the ATNF.

The Steering Committee expressed its confidence in a positive future for the ATNF and for Australian astronomy more generally.



# Director's report

**Dr Douglas Bock**
**Director, Australia Telescope National Facility**

Two thousand and sixteen (2016) was a year of consolidation and delivery for the ATNF. It was a period of relative calm after recent years, when the selection of the site for the Square Kilometre Array (SKA), technology choices for the SKA, and the need to fund the operational costs of the Australian SKA Pathfinder (ASKAP) had all required us to make significant changes to the ATNF's operations and direction.

In 2016 the Square Kilometre Array (SKA) project reached the middle of its 'pre-construction' phase. We are involved in several consortia and lead two. This was a $21.5 m activity, largely funded by the Department of Industry, Innovation and Science (over five years), but with co-investment by CSIRO. During the year, our consortium teams doubled down to deliver their allotted design work. We also supported Australia's negotiations to create the intergovernmental "SKA Observatory".

We began using ASKAP-12, a 12-antenna array using our latest phased-array feeds (PAFs), and delivering science with it. By the end of the year PAFs were deployed on 30 ASKAP antennas. These were major milestones in the ASKAP project and the entire team – everyone involved for the past decade – deserves congratulations.

Much of the work on ASKAP that led to this point took place under the leadership of Lewis Ball, who was the ATNF Director from March 2013 to March 2016. (The 2015 annual report contains an account of Lewis's Directorship.) In November I was privileged to be appointed to the role as Lewis's successor.

During the year we obtained funding to replace six first-generation ASKAP PAFs with the most recent model, so all 36 antennas will be equipped with the new feeds in 2017. The latest ASKAP PAFs are also influencing instrumentation on other telescopes. This year we completed an ASKAP PAF, built for the Effelsberg 100-m telescope in Germany, and commissioned it on Parkes. Pilot observations made with this instrument are described on page 34 .

Other aspects of the Parkes instrumentation program continued to forge ahead this year. We substantially completed the 0.7-4.2 GHz ultra-wideband receiver, which will be commissioned in 2017, and began development of a next-generation cooled PAF for Parkes.

At the Compact Array, the first two 'legacy projects' began in the October semester, and were allocated about 25 per cent of observing time. Legacy projects are large, coherent science investigations, not reproducible by any combination of smaller projects, that are intended to generate data of general and lasting importance to the broad astronomy community.

CSIRO funding for radio astronomy remained at approximately the same level for 2016 as for 2015, but other Commonwealth funding fell. The decrease was compensated for by the start of observing for Breakthrough Listen, a SETI (search for extraterrestrial intelligence) program, with funding from the Breakthrough Foundation of the USA. This program will be allocated 25 per cent of observing time on Parkes for the next five years. In line with recommendations from the ATNF Steering Committee, CSIRO is offering substantial fractions of telescope time for sale. Doing so allows us to present the broadest range of capabilities to users based on merit applications, within the available budget.

Our publication numbers remain very strong, with a slight decline within the typical year-to-year variation. This may reflect in part declining research staff numbers within CASS in recent years. Our publication impact continues to be underpinned by Compact Array and Parkes papers, but Long Baseline Array and Mopra publications are also strong. ASKAP publications are dominated by commissioning results.

In recent years, the response rates to our user surveys have been low and we have not published results. This was the case in 2016. However, we have introduced a simpler system and plan to resume reporting our results in 2017.

Late in the year there was public comment around allegations of bullying and harassment at CASS. Such behaviour is not acceptable. We have launched a review of our culture and environment and engaged with staff and stakeholders to prevent a recurrence. CASS aspires to be an employer of choice, with a diverse, safe and productive workforce.

Finally, I would like to acknowledge the support and advice given in 2016 by the Australia Telescope Steering Committee (ATSC), Users' Committee (ATUC) and Time Allocation Committee. They are critical to ensuring the ATNF telescopes provide high-impact science and that the ATNF responds to the needs of the user community. I would like to thank the all the members for their service, especially Sue Barrell (ATSC chair) and Virginia Kilborn (ATUC chair), whose terms ended in 2016.

# The ATNF in brief

Jolene Merry at work on an ASKAP antenna

Credit: Brett Hiscock

# The ATNF in brief

The Australia Telescope National Facility (ATNF) is a set of world-class radio-astronomy observatories operated by CSIRO (the Commonwealth Scientific and Industrial Research Organisation).

## MISSION

The ATNF's mission is to:

- operate and develop the Australia Telescope as a national research facility for use by Australian and international researchers
- exploit the telescope's unique southern location and technological advantages to maintain its position as a world-class radio-astronomy observatory, and
- further the advancement of knowledge.

**The 64-m diameter Parkes telescope, near the town of Parkes, New South Wales. Credit: John Sarkissian**

## LOCATIONS

ATNF observatories are located near the towns of Parkes, Narrabri and Coonabarabran in eastern Australia, and in the Mid West region of Western Australia. The ATNF is headquartered in Sydney, New South Wales, and has offices in Perth and Geraldton in Western Australia.

The Murchison Radio-astronomy Observatory (MRO) in Western Australia sits on land traditionally owned by the local Wajarri Yamatji community. CSIRO manages the MRO under an Indigenous Land Use Agreement (ILUA) for the site.

CSIRO also manages Australian astronomers' access to the antennas of NASA's Canberra Deep Space Communication Complex, which is located at Tidbinbilla in the Australian Capital Territory. These antennas are occasionally used in conjunction with ATNF telescopes.

## OPERATIONS

ATNF telescopes support a broad range of studies in Galactic (interstellar medium, pulsar, X-ray binaries, star formation, stellar evolution, magnetic fields), extragalactic (galaxy formation, interstellar medium, Magellanic Clouds, cosmic magnetism) and cosmological science.

The ATNF is a national facility, providing all astronomers at Australian and overseas institutions with the opportunity to use its telescopes. Access is given free of charge and is based on the scientific merit of the proposed observing project. This 'open skies' policy is the general practice of the international radio-astronomy community and Australian astronomers obtain access to overseas facilities on the same principle. In addition to national facility time, CSIRO has a multi-million dollar agreement with the Breakthrough Prize Foundation for the use of the Parkes radio telescope to search for extraterrestrial intelligence. The search will use 25 per cent of the telescope's time for five years from October 2016, and will return CSIRO the cost of operating the telescope during the observations and contribute to an upgrade of the data systems used for this and other science.

The proposals received each semester typically include about 550 authors: on average, about 60 are from CSIRO, 90 are from other Australian institutions and 400 are from 175 overseas institutions. The three overseas countries with the greatest numbers of proposers are the USA, UK and Germany.

About 65 per cent of the refereed publications derived from observations with ATNF telescopes result from collaborations between Australian and international researchers.


**Observatories and support sites for CSIRO radio astronomy**

**The Australia Telescope Compact Array, six 22-m diameter dishes near the town of Narrabri in New South Wales. Credit: David Smyth**

## GOVERNANCE

The ATNF comprises the major part of CSIRO Astronomy and Space Science (CASS), one of CSIRO's business units. CASS is part of CSIRO's Digital, National Facilities and Collections group, along with other national facilities that are owned and operated by CSIRO but used extensively by external researchers. CASS operates both the ATNF and the Canberra Deep Space Communication Complex, a station of NASA's Deep Space Network, on behalf of NASA. The Director of CASS is also the ATNF Director and is ultimately responsible to the Minister for Science, via the CSIRO Executive and the CSIRO Board.

ATNF policy is shaped by the Australia Telescope Steering Committee (ATSC), an advisory body that usually meets twice a year. The ATSC advises the Director on long-term strategy. It also appoints the Australia Telescope Users Committee (ATUC), which represents the interests of astronomers who use ATNF telescopes, and the Time Assignment Committee (TAC), which reviews observing proposals. The members of these three committees are listed in Appendix A.

## STAFF AND FUNDING

The ATNF receives CSIRO appropriation funding, supplemented by external (contract) funding. A financial summary appears in Appendix B.

In 2016 CSIRO employed about 200 staff on activities related to radio astronomy. Their names and locations are given in Appendix C.

**Antennas of the Canberra Deep Space Communication Complex. Credit: CDSCC**


**Antennas of the Australian SKA Pathfinder, ASKAP, at the Murchison Radio-astronomy Observatory in Western Australia. Credit: Brett Hiscock**

# Performance indicators

The Parkes telescope

Credit: Wayne England

# Performance indicators

## TELESCOPE USAGE

In the past, demand for telescope time has been higher in winter because the weather is better for higher-frequency (millimetre-wavelength) observations. However, with Mopra no longer operated as a National Facility telescope, and with more demand for the 7-mm band than the 3-mm band at the Compact Array, this seasonal variation no longer occurs. One hundred and fifteen (115) observing proposals were received for the summer semester (October 2015–March 2016) and 118 for the winter semester (April 2016–September 2016). The oversubscription rate (the factor by which proposals exceed the telescope time available) was 1.5 for the Compact Array and 1.3 for Parkes.

The Long Baseline Array (comprising Parkes, the Compact Array, Mopra, the Hobart and Ceduna telescopes of the University of Tasmania and occasionally other antennas) continued to be in demand, with proposals exceeding available time by a factor of two.

On both the Compact Array and Parkes, up to ten per cent of time is made available as 'Director's time'. This is time that is initially not allocated in the published version of the schedule, but which can be made available later for approved observing projects.

The key performance goals for the Compact Array and Parkes are:

- at least 70 per cent of telescope time be successfully used for observing
- no more than five per cent of observing time be lost through equipment failure.

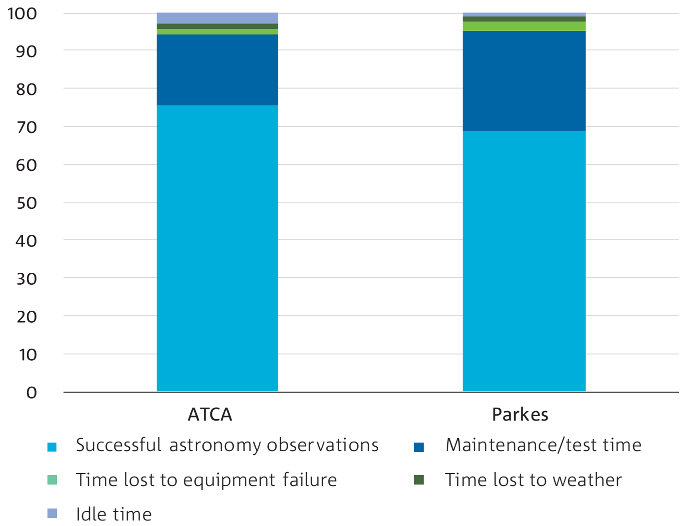



**Figure 1: ATNF telexcope usage 2016**

This year:

- time successfully used for observing was 69 per cent at Parkes and 75 per cent at the Compact Array. The main reason for Parkes dropping just below the key performance requirement is that during 2016 the telescope's multibeam receiver was removed and the phased array feed (PAF) purchased from CASS by the Max Planck Institute for Radioastronomy was installed for commissioning and characterisation, and some scientific observing. Maintenance blocks were required in advance to run optical fibre from the focus cabin to the telescope tower, and for the receiver change-overs. In addition, a block of several days was used to install and test a prototype next-generation ("rocket") PAF on Parkes
- time lost through equipment failure was two per cent at both Parkes and the Compact Array. Similar amounts were lost at both sites because of weather.

In addition, each year the antennas of the Canberra Deep Space Communication Complex (CDSCC) are available to be accessed for mutually agreed periods under a 'host country' arrangement between CSIRO and NASA. This year 135 hours were used for observing under these arrangements. CDSCC antennas are most in demand for Long Baseline Array observing, where it can be difficult to synchronise the required blocks of time around the antennas' primary activity, spacecraft tracking.

## TIME ALLOCATION

This year observing proposals were received from 790 individual researchers from 34 countries. Seventeen per cent were led by ATNF staff, 21 per cent by staff of other Australian institutions and 62 per cent by overseas researchers.

For the period from 1 October 2015 to 30 September 2016, 140 proposals were allocated time on ATNF telescopes (counting each proposal only once each calendar year even though some are submitted twice). This was fewer than in 2015 (when the figure was 156), partly because fewer proposals were received but also because more time was given to large projects. Eighty-three proposals were given time on the Compact Array, 38 on Parkes, and 14 on the Long Baseline Array: they are listed in Appendix D.

The ATNF also handles proposals requesting service observations with the 70-m and 34-m antennas of the Canberra Deep Space Communication Complex (CDSCC), part of NASA's Deep Space Network. Five CDSCC projects were observed during the year.

Time allocated to observing teams on the Compact Array and Parkes, broken down in different ways, is shown in Figures 2–5. ATNF staff were allocated about 18 per cent of observing time on the Compact Array and 31 per cent on Parkes. As can be seen from Figures 4 and 5, the fraction of observing time allocated to ATNF staff had fallen in the last few years (both because the number of astronomers on staff has fallen, and because these staff have a strong focus on commissioning ASKAP) but increased slightly in 2016.

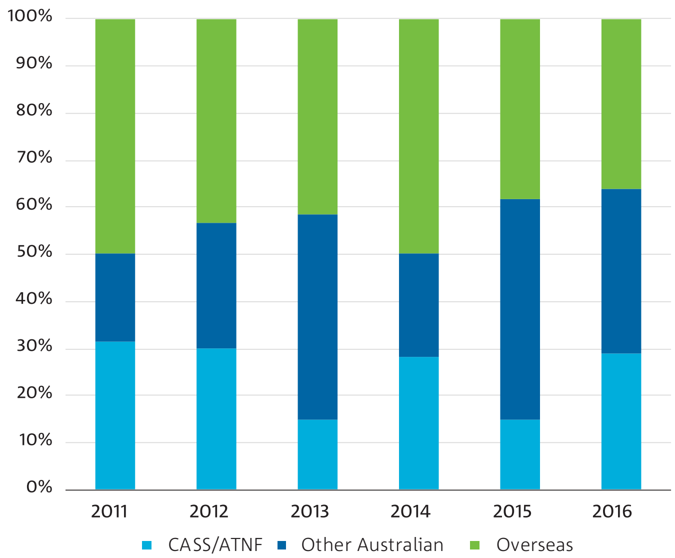



**Figure 2: Compact Array time allocation by primary investigator, October 2011–September 2015. For each year the time allocation is for 12 months from October to September.**

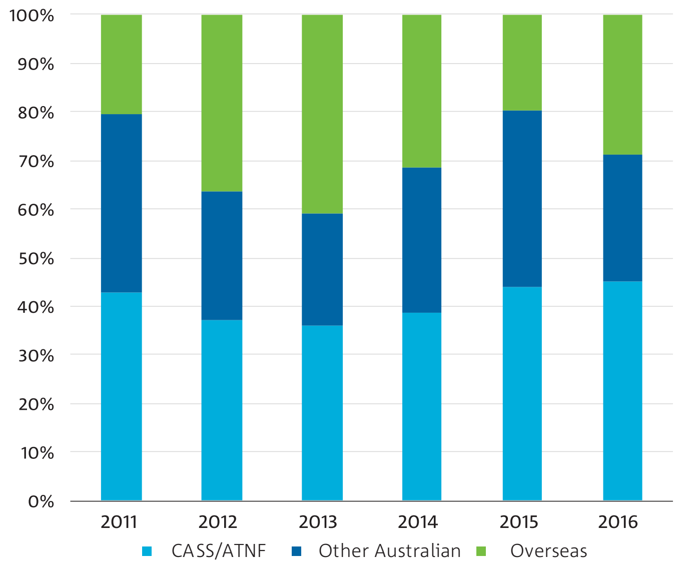



**Figure 3: Parkes time allocation by primary investigator, October 2011–September 2016. Time allocated to each proposal has been divided evenly between all authors on the proposal. For each year the time allocation is for 12 months from October to September.**

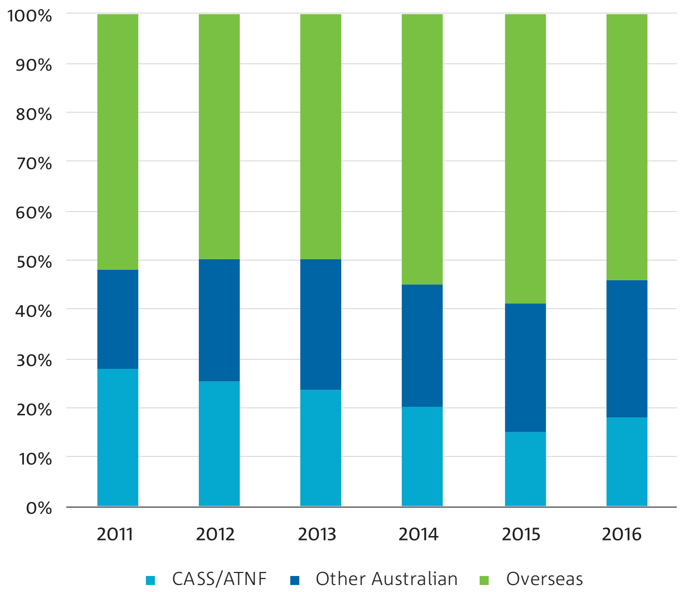



**Figure 4: Compact Array time allocation by all investigators, October 2011–September 2016. Time allocated to each proposal has been divided evenly between all authors on the proposal. For each year the time allocation is for 12 months from October to September.**

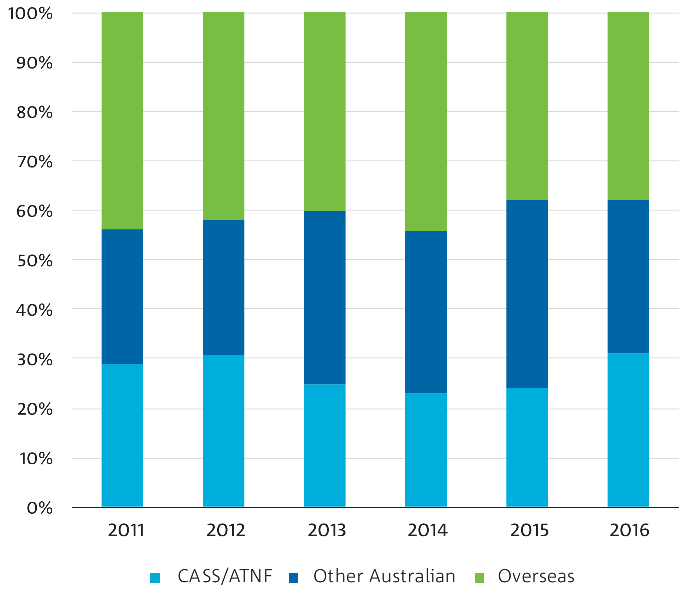



**Figure 5: Parkes time allocation by all investigators October 2011–September 2016. Time allocated to each proposal has been divided evenly between all authors on the proposal. For each year the time allocation is for 12 months from October to September.**

## TEACHING

As of December 2016, 25 PhD students were being co-supervised by ATNF staff. Their affiliations and thesis titles are given in Appendix E. Nine students were awarded PhDs during the year: their theses are listed in Appendix F. The number of co-supervised students has fallen since 2014 as a result of the departure of some Astrophysics staff who had supervisory roles and a continuing focus on commissioning ASKAP.

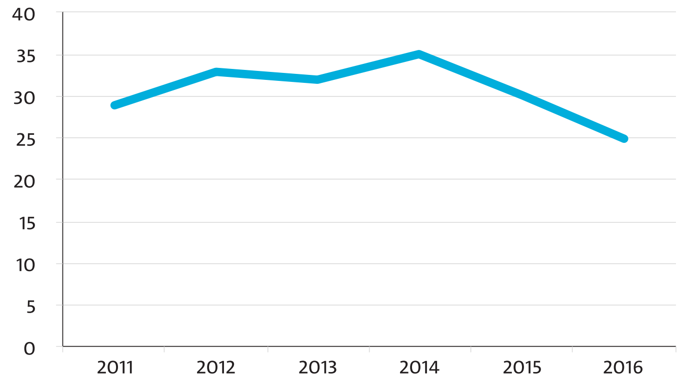



**Figure 6: Numbers of postgraduate students affiliated with CASS**

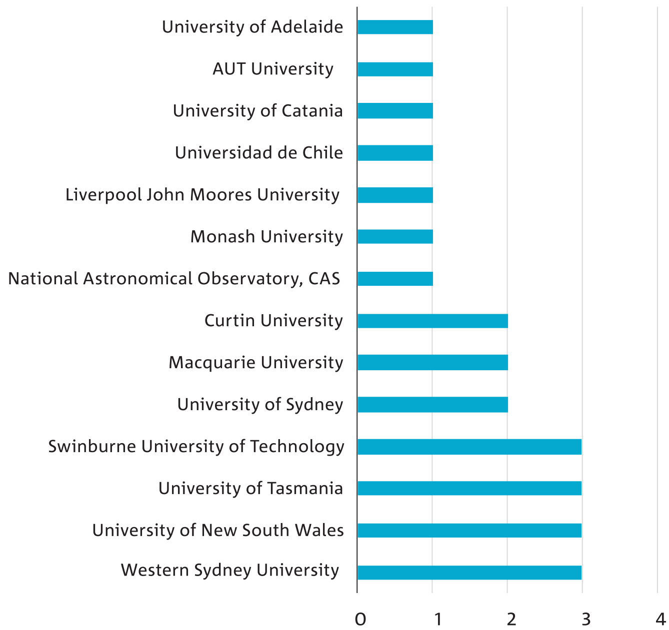



**Figure 7: Postgraduate student affiliations 2016**

## PUBLICATIONS AND CITATIONS

This year 129 papers using data from the National Facility were published in refereed journals. Approximately 65 per cent included a CASS author or authors.

In 2016 there were 163 refereed publications by CASS staff, including scientific papers with data from other facilities. In total, 220 refereed papers – both those using National Facility data and other papers by CASS staff – were published during the year. They are listed in Appendix G, together with 33 conference papers that were either derived from ATNF facilities or include CASS authors. The publication counts are a little lower than those of the previous year, probably due to a decline in the number of postdoctoral researchers in CASS.

Astronomy is Australia's leading physics discipline in terms of relative citation rate, and one of only two physics disciplines that performs above the European average (*Benchmarking Australian Science Performance*, Office of the Chief Scientist, 2013). One of the reasons for astronomy's success is its high level of international collaboration, which has been shown to positively influence citation performance in most disciplines. About 65 per cent of refereed CASS astronomy publications involve collaborations between Australian and international researchers, one of the highest proportions for all areas of CSIRO.

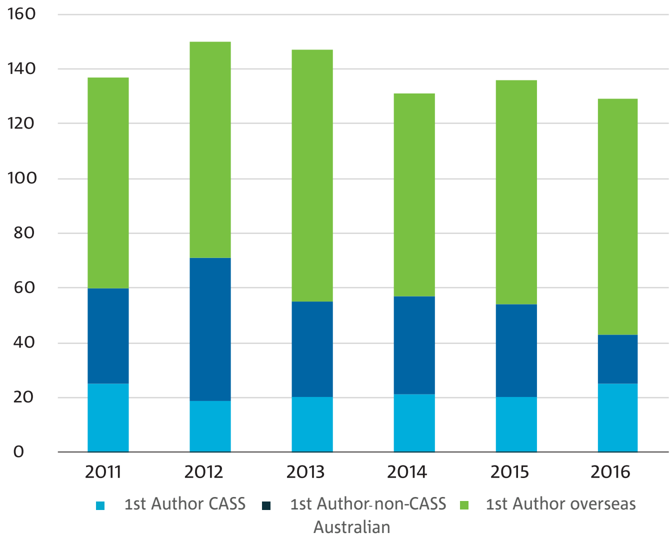



**Figure 8: Publications that include data from, or are related to, ATNF facilities (Compact Array, Mopra, Parkes, VLBI, Tidbinbilla and ASKAP), published in refereed journals during 2011–2016.**

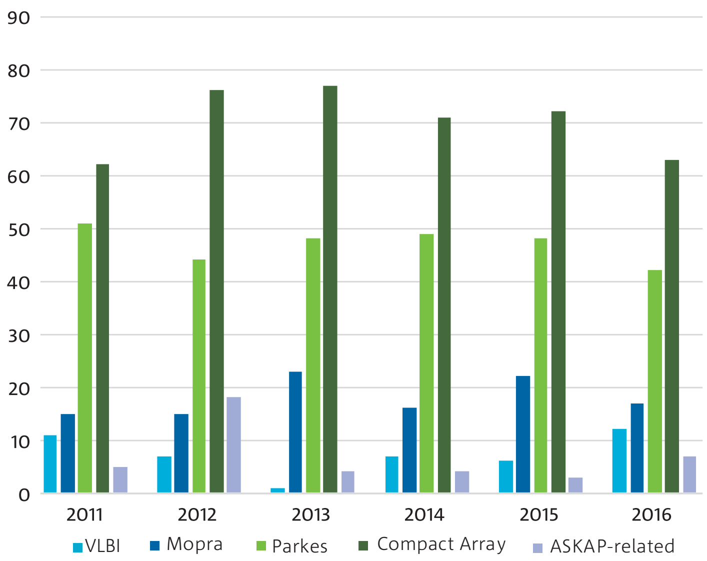



**Figure 9: Publications in refereed journals that include data from, or are related to, the Compact Array, Mopra, Parkes, VLBI and ASKAP, grouped by year for 2011–2016. A few papers with data from more than one facility are counted more than once.**

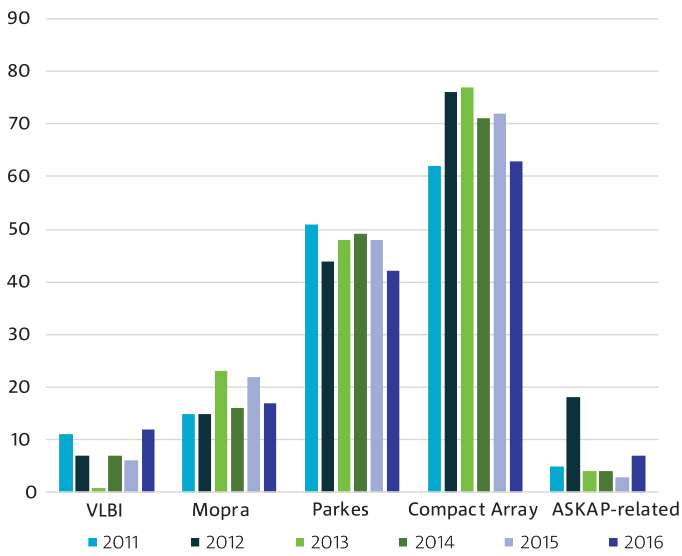
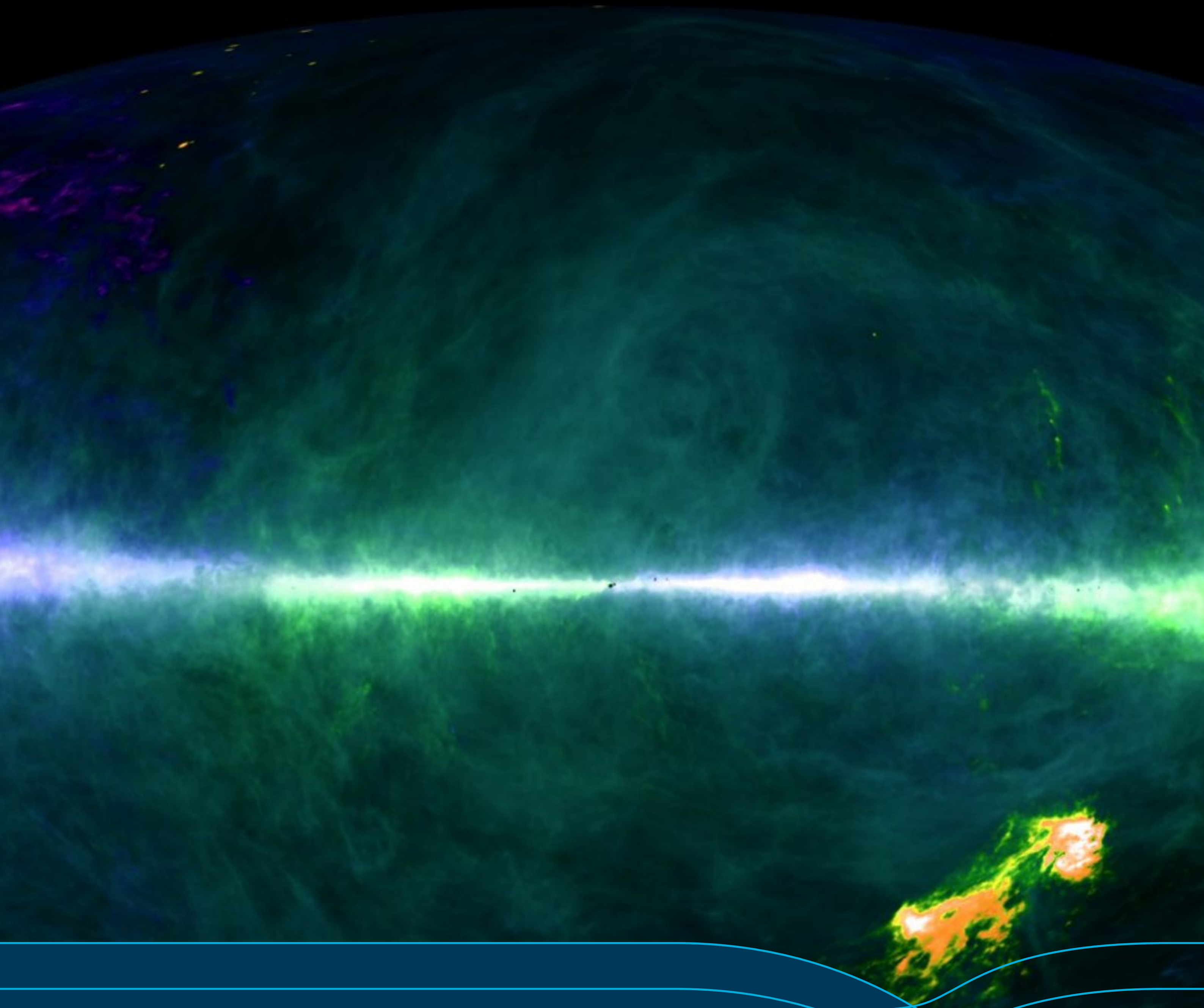



**Figure 10: Publications in refereed journals that include data from, or are related to, the Compact Array, Mopra, Parkes, VLBI and ASKAP, grouped by facility for 2011–2016. A few papers with data from more than one facility are counted more than once.**



# Science highlights

A detailed map of atomic hydrogen gas across the whole sky, made with the Parkes telescope and the Effelsberg telescope in Germany.

Credit: HI4PI Collaboration

**KEITH BANNISTER**
**(ATNF)**

## The Australia Telescope Survey for Extreme Scattering Events (ATESE)

### A new technique has allowed real-time discoveries of a rare phenomenon.

Extreme scattering events (ESEs) – periods of strong variations in the radio signals of active galactic nuclei (AGN) – were discovered in 1987. They are thought to signpost the presence of 'plasma lenses' in the Milky Way crossing the line of sight to the AGN. The strength of the lensing implies that the 'lenses' have extremely high column densities. ESEs can last for months, and no simple model of structures in the interstellar medium can explain how such high-column-density plasma can exist long enough to be observed.

These events have also been challenging to study: only about 20 were seen in the first three decades after their discovery. Of those three, only one was followed up with other observations while it was in progress, and none was observed at optical, X-ray or infrared wavelengths.

In April 2014 a team led by Keith Bannister (ATNF) began the Australia Telescope survey for Extreme Scattering Events (ATESE) project, with the aim of finding and following up ESEs in order to work out the geometry, size and composition of the plasma lenses and garner clues as to their origin. The search, which is continuing, involves observing about 1,200 AGN with the Australia Telescope Compact Array (ATCA) at intervals of a month.

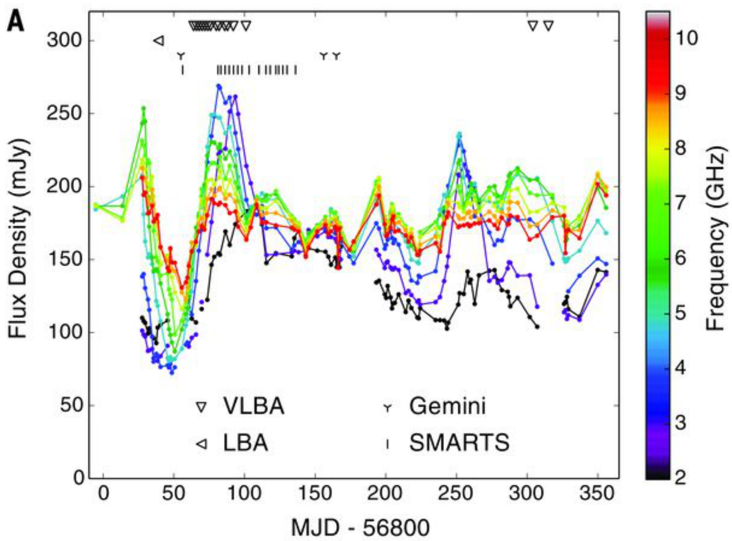
The key to the team's search method is that the strength of the lensing depends strongly on wavelength: during an ESE, the unremarkable power-law spectrum of an active galactic nucleus (AGN) – that is, a galaxy containing an active central black hole – turns into a highly structured one over the 4–8 GHz observing band. This is the first technique to allow an ESE to be identified in real time. Any ESE spotted is followed up with optical and radio observations, including very long baseline interferometry (VLBI).

Bannister's team has found three ESEs to date. The first, PKS 1939–315 (figure), came along just a few months after the survey started and has proved to be one of the longest-duration ESEs ever observed, lasting over 18 months. Follow-up observations made every three days with the ATCA showed that the spectrum varied wildly during the event. Theoretical modelling by Artem Tuntsov and Mark Walker (Manly Astrophysics) produced estimates of the column-density profile of the lens, while optical and VLBI monitoring set constraints on the dust content and the angular size of the lens on the sky.

The hunt for ESEs has turned up many other interesting phenomena, such as intraday variables (AGN that vary on hourly timescales), AGN flares, and some peculiar events that turn a regular positive-spectrum radio source into a faint, flat-spectrum one. A simple set of observations has led to a great deal that needs to be explained.

### PUBLICATION

**Bannister, K.W.; Stevens, J.; Tuntsov, A.V.; Walker, M.A.; Johnston, S.; Reynolds, C.; Bignall, H. "Real-time detection of an extreme scattering event: Constraints on Galactic plasma lenses". Science 351, 354 (2016)**




**Multifrequency light curve of PKS 1939–315, comprising nine 64-MHz channels centred every 1 GHz over 2–10 GHz. The thermal noise at each point is 0.5 mJy, less than the thickness of the lines. The symbols above the light curve indicate the days when follow-up observations were obtained using the VLBA, the Gemini 8-m telescope, and the SMARTS 1.3-m telescope. (From Bannister *et al*. 2016)**

# Largest galaxies form from 'star dew'


**BJORN EMONTS**
**(Centro de Astrobiologia)**


## The Compact Array has gathered evidence of how the Universe's largest galaxies form.

The largest galaxies sit at the centres of galaxy clusters (groups of hundreds of galaxies), like queen bees amid their workers. They are not the familiar spiral shape of our own Milky Way but are instead ellipticals, giant football-shaped masses of stars. Simulations suggest that these galaxies formed in a two-stage process: fattening up in the last ten billion years by cannibalising smaller galaxies, but initially growing by stars condensing directly out of large reservoirs of gas.

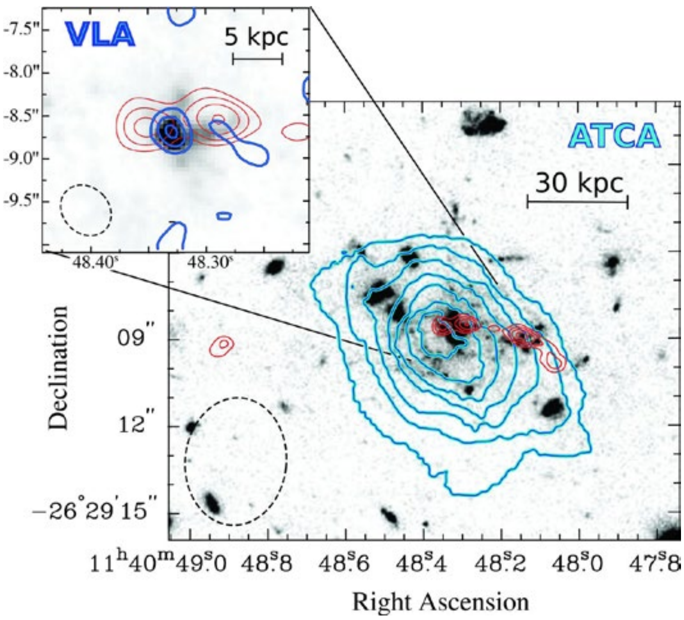
It is this early phase that an international team led by Bjorn Emonts (Centro de Astrobiologia, Spain) has found evidence for.

Emonts and his colleagues studied MRC 1138-262, the Spiderweb Galaxy, which is located in a protocluster at a redshift of 2.16 (about 10 billion light-years away). The Spiderweb is not a single galaxy but rather an aggregation of protocluster galaxies, one that will eventually merge and evolve into a single giant elliptical galaxy at the centre of the cluster. These galaxies are embedded in a giant halo of atomic (neutral and ionised) hydrogen gas, which radiates ultraviolet Ly$\alpha$ emission across a region of ~200 kpc.

Carbon monoxide (CO) traces the presence of molecular hydrogen, and is far easier to detect. Previous observations of CO in the Spiderweb had revealed large amounts of molecular hydrogen. To investigate it further, Emonts' team observed the $J$ = 1–0 transition of $^{12}$CO with the ATCA (90 h) and the Karl G. Jansky Very Large Array (VLA) in the USA (8 h). The ATCA observations, with a resolution of 4.8" x 3.5", were optimal for detecting broadly distributed CO with low surface brightness. The complementary VLA observations with a resolution of 0.7" x 0.6", were sensitive to small-scale features but not large ones.

The ATCA revealed CO in a region ~70 kpc across around the Spiderweb's central galaxy. By contrast, the VLA detected CO only within the central galaxy. This central emission accounts for only a third of the CO the ATCA saw: the remaining two-thirds is from gas outside the central galaxy, and is spread on scales larger than the individual galaxies of the protocluster. The large-scale CO does not peak in emission in the central galaxy or in the brightest surrounding protocluster galaxies; instead, the gas appears to be concentrated *between* the galaxies. The CO-emitting gas has a low velocity dispersion (~220 km s$^{-1}$), lower than that of the protogalaxies, and does not appear to be rotating. It is also extremely cold, about -200 C°. We seem to be seeing molecular hydrogen embedded in the Spiderweb's giant Ly$\alpha$ halo, and the Spiderweb looks to be condensing directly out of this gas.

Hubble Space Telescope imaging had previously suggested that the Spiderweb is forming stars within the gaseous halo at a rate of 142 $M_\odot$ per year. The CO discovered in the halo implies the presence of about a 100 billion solar masses of molecular hydrogen, which could sustain star formation in the Spiderweb galaxy until z~1.6. Even if the cold gas were replenished for another billion years, this quantity is consistent with predictions that the halo must stop forming stars by z=1, allowing the stellar population to age and attain the colours seen in central-cluster ellipticals in the local Universe.




**Molecular gas in the Spiderweb galaxy. $^{12}$CO ($J$ = 1→0) total-intensity contours from the ATCA (light blue) are overlaid onto a negative grayscale HST image. Red contours show the 36-GHz radio continuum from the VLA data. The inset shows the CO ($J$ = 0) total-intensity contours from the VLA (dark blue). (From Emonts *et al*. 2016)**


### PUBLICATION

**Emonts, B.H.C.; Lehnert, M.D.; Villar-Martín, M.; Norris, R.P.; Ekers, R.D.; van Moorsel, G.A.; Dannerbauer, H.; Pentericci, L.; Miley, G.K.; Allison, J.R.; and 12 co-authors. "Molecular gas in the halo fuels the growth of a massive cluster galaxy at high redshift". Sci., 354, 1128–1130 (2016).**

**KAREN LEE-WADDELL**
**(ATNF)**

# ASKAP begins Early Science observations

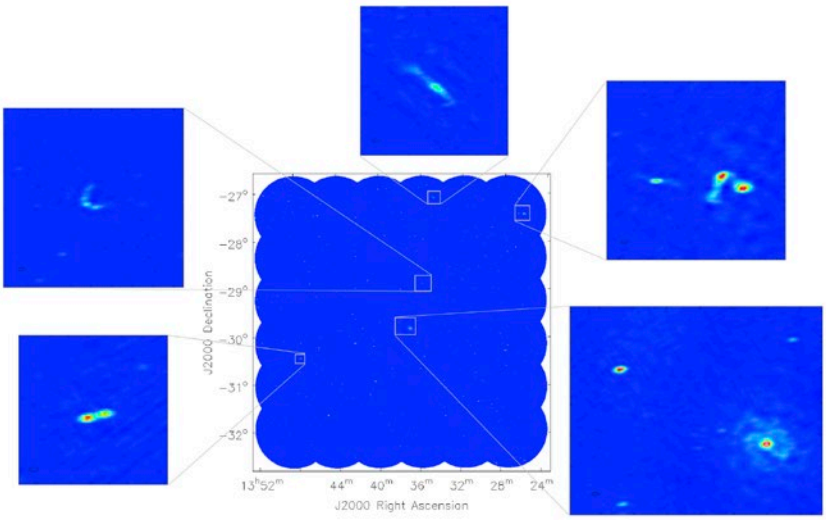
## ASKAP has begun its Early Science program, starting with observations for the WALLABY survey for neutral hydrogen.

WALLABY, the Widefield ASKAP L-Band Legacy All-sky Blind survey, is one of the major survey science projects ASKAP will carry out in its early years of operation. This survey has been designed to study the properties, environments and large-scale distribution of gas-rich galaxies: it will cover 75 per cent of the sky and is predicted to detect neutral hydrogen gas, H I, in more than 500,000 galaxies out to a redshift of 0.26. The large extent and homogeneity of WALLABY will allow us to examine in detail galaxy formation and evolution, the role of galaxy mergers and interaction events, the H I mass function and its relation with galaxy density, the physical processes governing cool gas at low redshift, cosmological parameters relating to gas-rich galaxies, and the nature of the 'cosmic web' (intergalactic gas). WALLABY will lay the ground for key science to be carried out with the future Square Kilometre Array. The survey is led by Bärbel Koribalski (ATNF) and Lister Staveley-Smith (University of Western Australia); the full WALLABY team comprises more than 100 astronomers from around the world, with a core group of ~20 having been particularly active to date.

With 36 fully functional ASKAP antennas, WALLABY will take 2–3 years of integration time (divided over ~1300 fields) to cover a declination range of $-90° < \delta < +30°$ with an angular resolution of 30 arcsec and a spectral resolution of 4 km $s^{-1}$. The expected survey rms of 1.6 mJy per beam per channel will provide sufficient sensitivity to detect low-mass dwarf galaxies (H I mass = $10^8 M_\odot$) out to a distance of ~60 Mpc and supermassive galaxies (H I mass = $10^{10} M_\odot$) out to the survey 'edge' at a distance of 1 Gpc. The significant data volume and large number of H I sources will require automated 3D source-finding algorithms to detect, extract, and fully characterize galaxies and other gas-rich features in the ASKAP datacubes.

ASKAP Early Science is an observing program to be carried out with at least 12 ASKAP antennas equipped with second-generation phased-array feeds: it is aimed at producing scientifically useful data while the telescope is being commissioned to full specification. Commissioning is likely to take at least a year from the start of Early Science and during that period ~20 per cent of the available telescope time (that is, 1800 hours) will be available for science observations. WALLABY has been allocated 800 hours of Early Science observing time, which will be used to observe 5–7 fields at the full WALLABY sensitivity and resolution. Integration times will vary according to the ASKAP array's properties and configuration.

After successful commissioning observations in August 2016, the WALLABY team produced detailed H I maps of the spiral galaxy, IC 5201. In October ASKAP officially started its Early Science program with WALLABY observations, led by Karen Lee-Waddell (CSIRO). By the end of 2016, four extragalactic WALLABY fields – the NGC 7232 group, the Fornax cluster, the Dorado group and a field centred on M83 – had been observed using ASKAP-12. This observing generated over 400 hours of H I data, which tested not only the current capabilities of the array hardware, but also all aspects of the queued scheduling (with remote operations using the ASKAP Observation Management Portal), data transfer and storage (using the Pawsey Supercomputing Centre), data processing and analysis with ASKAPsoft, and the eventual archiving and public release through the newly developed CSIRO ASKAP Science Data Archive (CASDA) system. Significant progress has been made towards developing the automated software required to run ASKAP and produce science-worthy results.




**An ASKAP Early Science continuum map of the region around M83, observed on 31 Dec 2016 and processed using ASKAPsoft. The central map shows the fully mosaicked 30-square-degree field of view that was simultaneously observed with 36 beams. The outer boxes highlight some of the features detectable after ~10 hours of observations using 10 ASKAP antennas (the number working at the time) with a 192-MHz bandwidth, and a 42 x 17 arcsec synthesized beam. The sensitivity and detail in these maps hint at ASKAP's scientific potential.**

### PUBLICATION

**Lee-Waddell, K. "Early Science results from ASKAP". (Accepted for the proceedings of the 32nd URSI General Assembly & Scientific Symposium, 2017)**

# A powerhouse of stars in the early Universe

**JINGZHE MA**
**(University of Florida) Photo: Lei Wang**

## The Compact Array has helped confirm the remarkable nature of a galaxy at redshift 5.66.

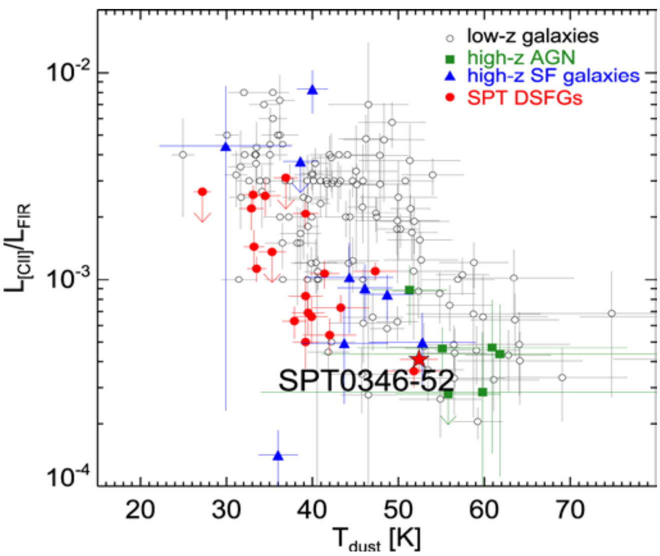
Dusty star-forming galaxies (DSFGs) house the most intense starbursts in the Universe. Often completely obscured at optical wavelengths, they have huge infrared luminosities which imply that each forms 100–1000 solar masses of stars per year. (For comparison, our Galaxy manages just one solar mass annually.) These objects are a key to understanding the assembly and evolution of massive galaxies in the early Universe. The South Pole Telescope (SPT) has found ~100 DSFGs, which have turned out to be brightened by gravitational lensing. The Compact Array is uniquely able to access the low-*J* CO lines (and so observe cool gas reservoirs) of galaxies at z=2–7, and has been used for a number of studies of SPT galaxies (e.g. Spilker *et al.* 2015; Aravena *et al.* 2016).

One galaxy in this sample, SPT0346–52, is among the highest redshift DSFGs known (z=5.66), placing it about a billion years after the Big Bang. During this phase of galaxy evolution, star-formation and the growth of supermassive black holes are thought to go hand-in-hand. There is a lensing model for SPT0346–52, which allows some of its intrinsic properties to be calculated. For its compact size ($R_{eff}$ = 0.61±0.03 kpc) SPT0346–52 turns out to have an extraordinary infrared luminosity (3.6 ± 0.3 × $10^{13}$ $L_\odot$) and star-formation rate (4500±1000 $M_\odot$ $yr^{-1}$): expressed as surface densities, these values are among the highest known for any galaxy. As the figure shows, the dust temperature of SPT0346–52 is higher than that of typical DSFGs. Does star formation account entirely for the galaxy's luminosity, or is an obscured active galactic nucleus (AGN) – that is, a black hole – at work, with gas falling towards the black hole becoming hotter and brighter?

To find out, Jingzhe Ma (University of Florida) and her collaborators used both NASA's *Chandra* X-ray space telescope and the Compact Array. Hard X-ray emission is a strong indicator of AGN activity; X-ray observations of another sample of DSFG galaxies showed that 17 per cent appeared to host an AGN. Radio too can be used to distinguish star-forming galaxies from AGN. Star-forming galaxies that are not radio-loud AGN follow a tight correlation between radio and far-infrared emission, with the formation of massive stars thought to be the phenomenon underlying both. This relation holds over five orders of magnitude in galaxy luminosity. Radio-loud AGN, in contrast, deviate from this correlation, showing higher levels of radio emission.

The *Chandra* observations of SPT0346–52 were consistent with a non-detection (with a 3σ upper limit of 6.0×$10^{-15}$ erg $cm^{-2}$ $s^{-1}$). Similarly, the Compact Array detected no continuum emission, and Ma and her team placed 3σ upper limits of 0.213 mJy at 2.1 GHz, 0.114 mJy at 5.5 GHz, and 0.138 mJy at 9.0 GHz on the radio emission from the source. The researchers also drew on a range of previous observations (from *HST*, *Spitzer* and *Herschel*) to fit the spectral energy distribution (SED) of SPT0346–52 with a range of models, to constrain the contribution an AGN might make. Pure star formation gave the best fit.

SPT0346–52 has an observed star-formation surface density ($\Sigma_{SFR}$) of 1540±130 $M_\odot$ $yr^{-1}$ $kpc^{-2}$. This is one of the highest values known for any galaxy in the Universe. What could account for it? DSFGs at redshifts above five, as SPT0346–52 is, are expected to harbour large gas reservoirs than those at lower redshifts and so may be able to sustain a higher star-formation efficiency. Also, Bothwell *et al.* (2016) found that SPT DSFGs (from a sample not including SPT0346–52) appear to have very high gas fractions on average ($f_{gas}$~0.6–0.8): these could raise the $\Sigma_{SFR}$. Whatever the explanation, SPT0346–52 is one of the most remarkable DSFGs found to date.




**$L_{[C\,II]}/L_{FIR}$ vs. $T_{dust}$. The red circles are SPT dusty star-forming galaxies. The low-*z* and high-*z* samples are compiled by Gullberg *et al.* (2015). SPT0346–52 (red star) lies in the region surrounded by AGN-dominated galaxies. (From Ma *et al.* 2016)**

### PUBLICATION

**Ma, J.; Gonzalez, A.H.; Vieira, J.D.; Aravena, M.; Ashby, M.L.N.; Béthermin, M.; Bothwell, M. S.; Brandt, W.N.; de Breuck, C.; Carlstrom, J.E.; and 13 co-authors. "SPT0346–52: Negligible AGN activity in a compact, hyper-starburst galaxy at z = 5.7". ApJ, 832, A114 (2016)**


**VANESSA MOSS**
**(University of Sydney)**


# Finding hidden H I in the Milky Way's halo

## Comparing two surveys of H I (neutral hydrogen gas) in the Milky Way's halo has led researchers to conclude that diffuse gas outweighs dense gas by up to a factor of three.

Gas in our Galaxy is in a constant state of change: falling in from the interstellar medium, being expelled from the disk by the play of star formation, and circulating. Among the best-studied components of our Galaxy's 'gas economy' are the bright, prominent high-velocity clouds (HVCs) that scoot around the Galactic halo. Some researchers (e.g. Nigra *et al.* 2012) had found hints that the bright HVCs might be embedded within a faint, diffuse background of H I. Vanessa Moss (University of Sydney) and her colleagues set out to explore the structure of this less-studied faint H I in the Milky Way's halo.

Moss's team drew on two H I surveys of the Galaxy: a study by Lockman *et al.* (2002), carried out with the 43-m telescope at NRAO's Green Bank Observatory, and the Galactic All Sky Survey (GASS), made with the 21-cm multibeam system on the Parkes radio telescope. Lockman *et al.* searched for faint high-velocity H I lines in 860 directions, with a median rms sensitivity of 3.4 mK. The GASS survey, on the other hand, covered the entire southern sky but at a lower sensitivity (rms ~57mK). Because of their different characteristics, the two surveys preferentially detect different forms of neutral gas. Inspecting the two datasets by eye reveals two populations: bright clouds with narrow spectral lines and a fainter population with broader spectral lines.

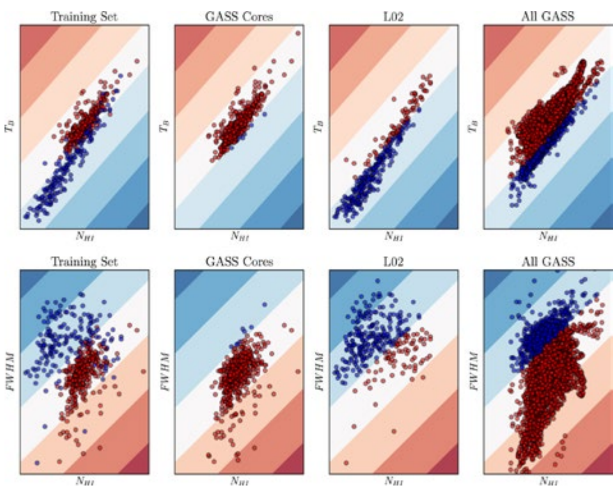
Moss and her team investigated how these dense and diffuse components were spatially distributed. First, they had to systematically classify the H I components as being either dense or diffuse. This they did with a machine-learning technique known as linear discriminant analysis (LDA), training the system with two sets of data: the cores of the HVCs found in the GASS survey and the Lockman *et al.* distribution (representing dense and diffuse gas respectively). They then applied the machine-learning tool to the whole GASS dataset, analysing three properties: brightness temperature, spectral-line width and column density.

The shallow GASS is less sensitive to faint, diffuse H I than the deeper Lockman *et al.* survey. The H I components detected by GASS were found to be 90 per cent dense and 10 per cent diffuse. Diffuse components were most commonly seen at the edge of HVCs (typically about three times further from an HVC core than a dense component); only one per cent of components consisted solely of diffuse material. The researchers also generated the average and median H I spectra of both gas types. The average spectrum for dense components was close to the standard spectrum of HVCs known from other surveys. The diffuse spectrum, however, is both fainter and broader. Thermal broadening alone cannot account for its width; turbulence appears to be the main cause. Both dense and diffuse H I are found all over the high-latitude sky, with no region being preferred.

The key to the ongoing puzzle of how the Galaxy accretes gas may lie in the question: which component accounts for the greatest mass of H I, dense or diffuse? The Lockman *et al.* study, which randomly sampled the halo gas to high sensitivity, is a better measure of the dense to diffuse ratio. Conversely, the ten thousand averaged GASS spectra better measure the average column density of each population. Combining these, Moss and her team concluded that the total mass of the diffuse H I is probably three times that of the dense H I, and thus contributes significant neutral mass to the Galactic halo.

### PUBLICATION


**Moss, V.A.; Lockman, F.J.; McClure-Griffiths, N.M. "Tracing dense and diffuse hydrogen in the halo of the Milky Way". ApJ, 834, 155 (2017)**


**Linear discriminant analysis (LDA) results in 2D for f($T_B$, $N_{H\,I}$) and f(FWHM, $N_{H\,I}$). The far-left panels shows the training subset (60%) taken from the combined sample of GASS cores and the Lockman *et al.* (L02) sample, while the middle panels show the result of applying the classifier to these two complete sets after training. The far-right panels show the classification results for the entire GASS sample. (From Moss *et al.* 2017)**

# Brilliant fast radio burst probes intergalactic gas

**VIKRAM RAVI**
**(Caltech)**

Researchers have used a remarkable flash of radio waves to measure the magnetic field and turbulence of the gas that lies between galaxies.

Lasting just a few milliseconds at most, fast radio bursts (FRBs) appear to originate well beyond our Galaxy, perhaps as far as halfway across the Universe. The 20-odd bursts found since 2007 are outnumbered by ideas as to their origin. But even without knowing how they arise, we can use them as probes of the intergalactic medium, the rarefied gas between the galaxies. An international team jointly led by Vikram Ravi (Caltech) and Ryan Shannon (CSIRO/Curtin University) has used an extraordinarily bright FRB to measure the magnetic field and turbulence of this intergalactic gas.

FRB 150807 was discovered using the 21-cm multibeam receiver on the Parkes telescope, coupled with a real-time detection system developed by Swinburne University of Technology. This burst was extreme in several ways. It lasted for just a third of a millisecond, making it one of the shortest FRBs known. It was also extraordinarily bright, with a peak flux density of 120 ± 30 Jy, making it the second-brightest FRB ever seen. At the same time, it had a low dispersion measure (a measure of the number of free electrons along the burst's path): at 266.5 ± 0.1 cm$^{-3}$pc, it was the lowest ever reported for an FRB. The burst spectrum shows structure on a scale of ~100 kHz: this may be scintillation (twinkling) cause by free electrons along the burst's path of travel and, if so, it is the weakest ever measured for an FRB. Finally, FRB 150807 was strongly linearly polarised (80 ± 1%).

The burst was detected in two adjacent beams of the receiver, allowing Ravi and Shannon to constrain its position to a 9 arcmin$^2$ region and so look for stars and galaxies that it might be associated with. The deepest archival images showed nine bright objects, three stars and six galaxies, in the region. The brightest galaxy is at a distance of 1–2 Gpc while the other galaxies are more than six times fainter and are all thought to be at least 500 Mpc distant. If FRB 150807 originated in a galaxy, that galaxy, if sizeable (<10$^9$ solar masses) is likely to lie at a distance of more than 500 Mpc.

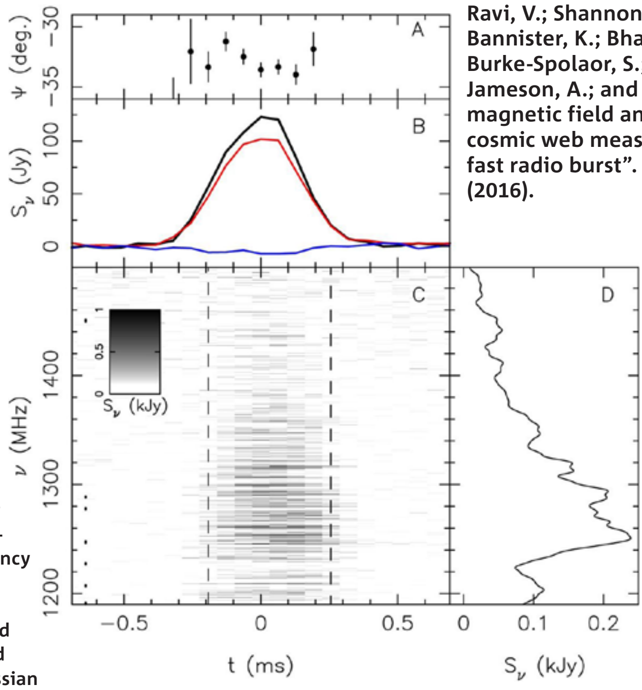
When a linearly polarised radio signal travels through a magnetic field, its plane of polarisation is 'twisted' (a phenomenon called *Faraday rotation*).

Comparing the rotation measure of FRB 150807 with that of a pulsar nearby on the sky showed that the FRB had undergone little Faraday rotation before reaching our Galaxy. From this the researchers inferred that the gas around the origin of the burst was not magnetised, or scarcely so; they also determined that the intergalactic gas must be only weakly magnetised (<21 nG). This weak magnetic field is consistent with predictions from many models for the intergalactic gas; interestingly, it is also inconsistent with the FRB coming from an object embedded in a highly magnetised star-forming region or the centre of a galaxy. The burst's weak scintillation suggests that the intergalactic medium is slightly, rather than strongly, turbulent.

Despite its extreme properties, FRB 150807 could be drawn from the same source population as the majority of FRBs. If this is so, it strengthens the case for most FRBs being of cosmological origin. The event with the second-lowest dispersion measure, FRB 010724, was detected in four beams of the Parkes multibeam system, implying a fluence comparable to that of FRB 150807. This in turn suggests that an FRB's dispersion measure may correlate with source distance – just what would be expected if host galaxies contribute little to the dispersion measure and the source population is cosmologically distributed.

**PUBLICATION**

**Ravi, V.; Shannon, R.M.; Bailes, M.; Bannister, K.; Bhandari, S.; Bhat, N.D.R.; Burke-Spolaor, S.; Caleb, M.; Flynn, C.; Jameson, A.; and six co-authors. "The magnetic field and turbulence of the cosmic web measured using a brilliant fast radio burst". Science, 354, 1249–1252 (2016).**




**Polarisation and spectral properties of FRB 150807. (A) Absolute position angle (ψ) of the electric field polarisation vector. (B) Total intensity (black), linear polarisation fraction (red), and Stokes V (blue) time-series profiles of the burst, averaged over all frequency channels. (C) De-dispersed dynamic spectrum of the burst. The small bars on the left of the plot show frequency channels removed because they contained radio-frequency interference. (D) The time-averaged spectrum of the burst, smoothed with a 5-MHz Gaussian filter. The time-resolution of the data in (A), (B), and (C) is 64 μs, and the frequency-resolution of the data in (C) and (D) is 390.625 kHz. (From Ravi *et al.* 2016)**

# Tighter pulsar timing gives exquisite star distance

**DANIEL REARDON**
**(Monash University)**

## Researchers have 'tuned' their models for pulsar timing, greatly improving measurements of mass, distance and other parameters for a key set of pulsars.

By definition, pulsars pulse: their radio beams sweep over us as they spin. Most pulsars have been found by picking out their train of pulses from a sea of radio noise. The main goal of a pulsar timing array (a set of pulsars whose pulse arrival times are recorded with great precision) is to search for gravitational waves of nanohertz frequency. But there are many other secondary goals: testing general relativity, for instance, and measuring properties of the pulsars themselves.

To make such tests, researchers compare the pulse arrival times that they measure with those predicted by timing models. A timing model takes into account the factors known to influence the arrival times, such as the nature and motions of the pulsar and any companion star it has and how pulses propagate through the interstellar medium. The parameters of the timing model are determined by fitting the model to the pulse arrival times.

Discrepancies between the model and the measurements are known as timing residuals. They have many causes: for instance, measurement errors, errors in the assumed masses of planets in the solar system and, particularly, random fluctuations in the apparent spin rate of the pulsar. Daniel Reardon (Monash University) and colleagues have improved the pulsar timing solutions for a key set of 20 millisecond pulsars observed as part of the Parkes pulsar timing array (PPTA) program.

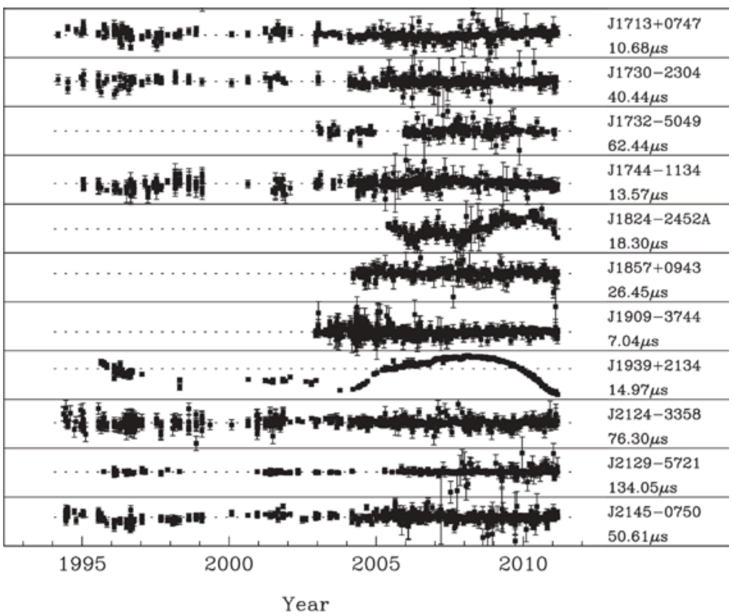
The best previous timing models for these pulsar were based on Parkes observations, taken at 20 cm only, and published in 2009. Later PPTA observations, still ongoing, have been made at three wavebands (10, 20 and 50 cm) and with more modern instrumentation. Reardon and his colleagues have now combined the earlier dataset with a more recent one and reanalysed the combined data.

An important kind of timing noise, dispersion measure noise, is caused by variations in the number of free electrons the radio pulses encounter as they travel through the interstellar medium. The effect is stronger at lower wavelengths. Because the later PPTA observations were made at three observing wavebands, it had been possible to measure this noise and remove it from that dataset. But the earlier, archival observations could not be corrected this way.

In their new work, Reardon and his colleagues modelled the extra dispersion measure noise in the earlier data, and combined this model with a second one for noise arising from variations in the pulsar's spin. Using these new noise models with the longer dataset, they reduced the uncertainties on a number of parameters in the timing models for the 20 pulsars. This produced the first significant parallax measurements for five of the pulsars, the first significant measurements of some orbital parameters for six, and better mass measurements. In particular Reardon's team was able to refine the distance of PSR J0437–4715 to 156.79 ± 0.25 pc: with an uncertainty of just 0.16 per cent, this is one of the most precise distances known to any star – and, crucially, for the first time the uncertainty is smaller than the wavelength of the gravitational waves the PPTA is searching for. Knowing the distance with this precision improves the PPTA's ability to search for continuous gravitational waves and identify their source. Over time, Parkes observations will be used to obtain similarly exquisite precisions for more pulsars.

### PUBLICATION

**Reardon, D.J.; Hobbs, G.; Coles, W.; and 18 co-authors. "Timing analysis for 20 millisecond pulsars in the Parkes Pulsar Timing Array." MNRAS, 455, 1751–1769 (2016)**




**Post-fit residuals for 11 of the pulsars analysed by Reardon *et al.* (2016). The vertical range of each subplot is given below the pulsar name.**


**LISTER STAVELEY-SMITH**
**(University of Western Australia)**


# Galaxy surveys in the Zone of Avoidance

## A blind H I survey of the extragalactic sky behind the southern Milky Way has revealed new galaxies in this 'Zone of Avoidance'.

As long ago as the 19th century it was recognised that galaxies (or 'nebulae' as they were then called) are harder to find at low Galactic latitudes. We now know this is because they lie at large distances and, close to the Galactic Plane, their light is obscured by dust particles. Infrared surveys such as IRAS, 2MASS and WISE have been able to narrow this Zone of Avoidance (ZoA), from ±10° to ±5°, but not eliminate it. They have also not been able to provide the redshifts required for estimating galaxy distances.

In the late 1990s an international team of researchers began using Parkes to 'fill in' the southern Zone of Avoidance, making use of the sensitivity and field of view provided by Parkes' then-new 21-cm multibeam receiver.

They measured the redshifted 21-cm line of neutral hydrogen (H I) from galaxies in the region, radio waves being unaffected by dust obscuration or stellar crowding.

The well-known H I Parkes All-Sky Survey (HIPASS – Barnes *et al.* 2001; Meyer *et al.* 2004) provided the first shallow H I survey of the region. But it was soon recognised that deeper observations were required in order to accurately probe large-scale structure in the distance interval 40 to 100 Mpc. This is an important interval, because the Universe is not homogeneous on scales smaller than 100 Mpc, and large clusters and superclusters in this range have an important influence on the dynamics of nearby galaxies. Furthermore, the most massive galaxy concentrations in the nearby Universe, the Hydra-Centaurus and Shapley superclusters and the enigmatic Great Attractor, all lie in or near the ZoA.

Multibeam surveys of increasing depth and coverage within the ZoA have been conducted over several years at Parkes (Henning *et al.* 2000; Juraszek *et al.* 2000; Donley 2005), and have together identified the positions and redshifts of more than 1000 galaxies. Most of these (883) have been compiled in a recent publication (Staveley-Smith *et al.* 2016) which, at Galactic longitudes less than 36° and higher than 212°, supersedes earlier catalogues. Very few of the galaxies detected had optical redshifts previously measured but around half had some form of optical or near infrared counterpart already recorded in the literature. The newly catalogued galaxies are shown in Figure 1.

Overall, no new nearby massive objects like the Circinus Galaxy were found. However, HIZOA J1353–58 was found to have a projected distance of less than 600 kpc from the Circinus Galaxy, and so is a possible companion (the only one known). On a larger scale, three new galaxy concentrations (NW1, NW2 and NW3) were found, which confirm the diagonal crossing of the Great Attractor Wall between the Norma and CIZA J1324.7–5736 clusters. Two additional complexes (CW1 and CW2) were found in the nearby Centaurus Wall. The spatial and redshift distribution of the new galaxies and galaxy structures are shown in Figure 2.

H I studies in the ZoA will be advanced even further by the WALLABY survey being carried out with ASKAP. This southern hemisphere study will be complemented by similar surveys with the WSRT/APERTIF and FAST radio telescopes in the north, making the census of galaxies around the Milky Way truly complete.

### PUBLICATION


**Staveley-Smith, L.; Kraan-Korteweg, R.C.; Schröder, A.C.; Henning, P.A.; Koribalski, B.S.; Stewart, I.M.; Heald, G. "The Parkes H I Zone of Avoidance Survey". AJ, 151, A52 (2016)**

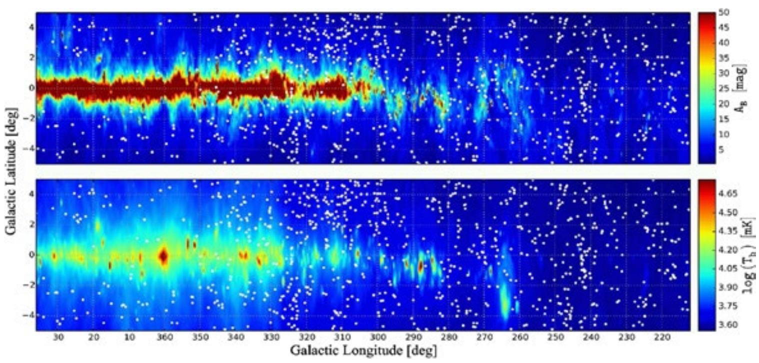




**Figure 1: Galaxies (white dots) discovered in the blind H I ZOA survey overlaid on a map of Galactic extinction (top panel) and Galactic 1.4-GHz continuum emission (bottom panel). Galaxies can be detected in the areas of deepest optical extinction. (From Staveley-Smith *et al.* 2016)**

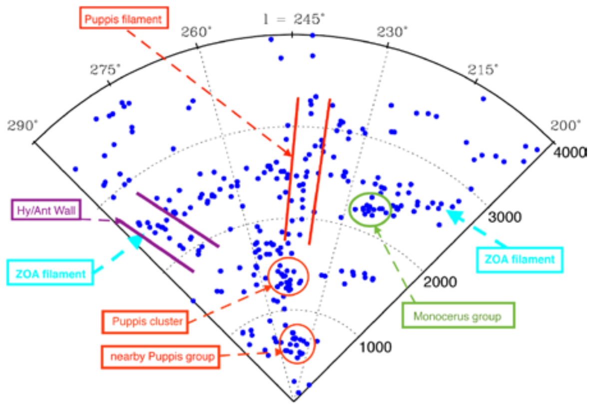



**Figure 2: A polar (wedge) plot showing galaxies in the dense 'Great Attractor' region as a function of Galactic longitude and distance. Some newly defined structures are marked. (From Staveley-Smith *et al.* 2016)**

# Observatory reports

The Australian SKA Pathfinder, ASKAP.

Credit: Australian SKA Office

# Observatory reports

## Compact Array

The October semester saw the first observing time scheduled for the new, large ATCA Legacy Projects. Of the eleven proposals submitted, the special international time assignment committee assembled to assess them chose four that should be supported by the observatory. The committee recommended two to be given the highest priority when scheduling:

- GAMA Legacy ATCA Southern Survey (GLASS), a wide and deep 4-cm survey of the well-studied GAMA G23 field
- Imagine Galaxies Intergalactic and Nearby Environment (IMAGINE), a 16-cm survey of 30 nearby galaxies spanning a range of masses and environments.

These two projects received between them 1000 hours of observing time (about a third of the total observing time available) in the 2016OCT semester.

Another two Legacy Projects are to be supported at a lower priority:

- Dense Gas Across the Milky Way: the 'full-strength' MALT45, a 7-mm survey of dense gas in the fourth quadrant of the Galactic plane
- A Comprehensive ATCA Census of High-Mass Cores, a 15-mm study of 123 young, high-mass molecular clumps.

These second two projects, which involve observations in the 7-mm band, will be started in the 2017APR (winter) semester. The first two projects will continue in that semester and between them the four will receive 1200 hours of observing time (about 40 per cent of the total available time).

We made a few technical fixes and upgrades to the array this year. Several antennas required new or refurbished travel motors (those that move the antennas along the track). The 'anaconda' systems, which allow the cables in an antenna's vertex room to move smoothly when the turret rotates, had their cable sheaths and bearings replaced. To prevent corrosion, the antennas' handrails and the area above the alidade level were repainted. We started a program to replace the primary monitor (PMON) system, and aim to have a system similar to Parkes' telescope protection system (TPS) installed in 2017.

With the 4-cm feedhorn rollout almost complete, we made a study to determine the optimal focus positions. This showed that the new horns are focused at a single subreflector position across the entire 4–12 GHz frequency range, which is a substantial improvement over the original 6/3-cm feedhorns.

Now that ALMA (the Atacama Large Millimeter/submillimeter Array) is observing in the 3-mm band, support for the Compact Array's 3-mm systems will be offered a 'best efforts' basis (that is, there will be no guarantee of repairs to any systems that break). This may mean that a full dual-polarisation array will not be available for 3-mm observations in future.

Some interesting new radio-frequency interference (RFI) was discovered coming from the Sky Muster satellites, which the National Broadband Network launched in late April to provide internet to rural Australians (and Qantas flyers). The appearance of this RFI required us to change our recommended 15-mm continuum frequencies. There was also a short-term plague of RFI associated with the release of Pokémon Go, a location-based game in which players use GPS systems to find and capture virtual creatures called Pokémon. A couple of significant Pokémon Go locations (PokéStops and a 'gym') were located near the observatory's visitors centre, and requests to the game's developer to remove them went unheeded.

In July the dual-IF design of the Compact Array was used to great effect to demonstrate the success of a prototype of the SKA phase-transfer system, designed by a team from the University of Western Australia. During the tests, we learned about our own system, as we found that the relative phase stability of our central local oscillators was very susceptible to blasts of cold air from the screened-room air conditioners.

It was hot air however, and the installation of temperature-monitoring equipment in the Compact Array seeing-monitor cabinets, which caused us to shut down the seeing monitor for long periods at the end of the year. A new cooling system for these cabinets is being designed.

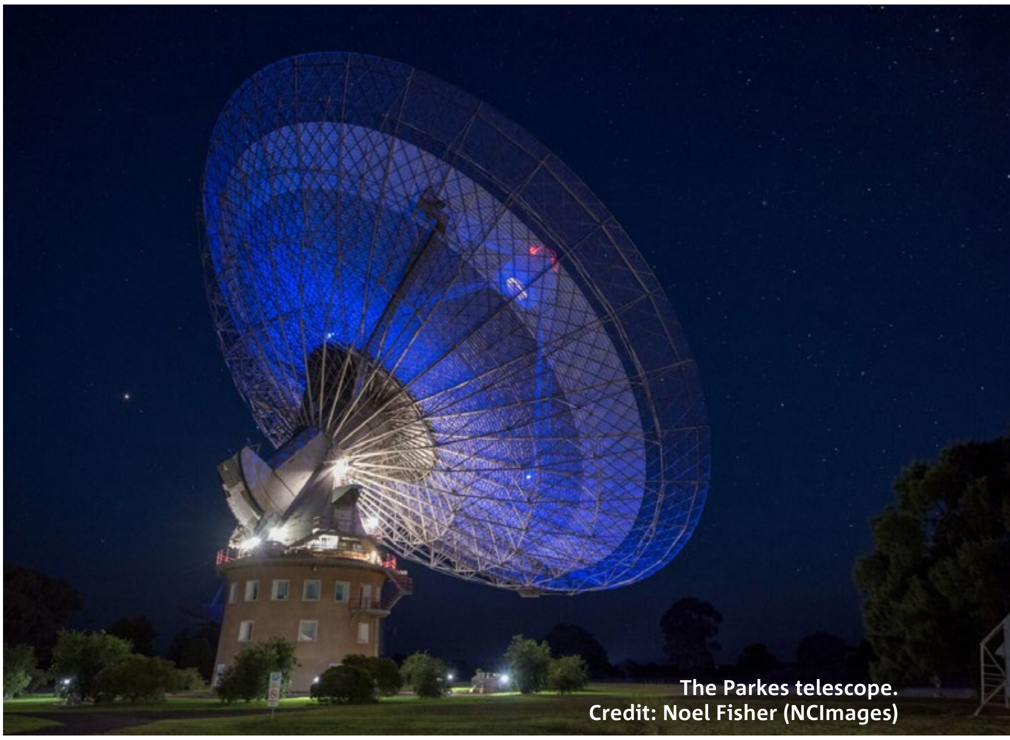

The Compact Array.
Credit: Attila Popping

## Parkes

The Parkes telescope experienced a fruitful year of scientific discovery, including:

- the detection of the first interstellar chiral molecule, propylene oxide, one of the foundations for life on Earth (McGuire *et al.*, Science, 352, 1449) and
- further progress in the field of fast radio bursts, in polarisation with Ravi *et al.* (Science, 354, 1249), and in proposed host galaxy association with Keane *et al.* (Nature, 530, 453).

It was also a particularly busy year for technological development. In February, the 20-cm multibeam receiver was removed from the focus cabin (for only the third time since its original installation in 1997) and a phased-array feed (PAF) was installed. This PAF was a slightly modified version of the second-generation PAFs for ASKAP, and had been purchased by the Max Planck Institute for Radioastronomy (MPIfR) for use on the Effelsberg 100-m telescope from 2017. It was installed on Parkes as part of its commissioning and testing, and here it was put through its paces for many projects: pulsar timing (including three pulsars simultaneously in three beams), searching for fast radio bursts, and fast intensity mapping of neutral hydrogen gas (H I). Its last hurrah, before being removed and shipped to Germany, was in a VLBI (very long baseline interferometry) experiment, in conjunction with a PAF on an ASKAP antenna. This was the first demonstration of VLBI using two PAFs.


The Parkes telescope.
Credit: Noel Fisher (NCImages)

In April the international SKA Organisation designated Parkes as an SKA Pathfinder (that is, a telescope that carries out SKA-related technology, science and/or operations), on the basis of its role in testing PAFs and wideband feed technology. In addition to the MPIfR PAF work, a prototype third-generation ‘rocket’ PAF was temporarily installed after the MPIfR PAF for testing, which has informed a proposal to install a cryogenically cooled, next-generation PAF on Parkes in subsequent years (page 35). Design work has also continued on the ultra-wideband feed, for installation on Parkes in 2017 (page 34).

In 2015 it was announced that Parkes would be a key element of *Breakthrough Listen*, a search for extraterrestrial intelligence (SETI) program funded by the Breakthrough Prize Foundation. This year representatives of the Breakthrough Prize Foundation and of the University of California Berkeley, which is leading the SETI search, visited Parkes several times. In February they spent time discussing the project’s requirements with local staff and installing test equipment; September saw a second visit and the installation of backend equipment to enable observing with a single-beam receiver: this observing officially commenced in November, following test observations in October. The multibeam backend system is scheduled to be re-installed in 2017 for surveys of the Galaxy. *Breakthrough Listen* will use 25 per cent of the available observing time on Parkes each year, for at least five years. Discussions are under way about science projects that can be done commensally.

Parkes’ backend capability changed during the year. A new GPU-based system was installed, initially to accommodate the needs of the MPIfR PAF: it is now under development for the ultra-wideband feed and the suite of existing receivers. This installation, and the advent of Breakthrough Listen, made it necessary to remove the older DFB3 and multibeam correlator systems.

The 12-m antenna at the Parkes observatory was used this year to monitor the Vela pulsar, almost daily, with a second-generation PAF. These observations demonstrated that a pulsar can be timed with a PAF system; showed that the beam weights were stable to one per cent over periods of three weeks; and, in December, detected a glitch in the Vela pulsar (Sarkissian *et al.* PASA, submitted).

## Long Baseline Array

The ATNF's Long Baseline Array (LBA) is a set of telescopes used together for simultaneous observations, a technique called very long baseline interferometry (VLBI). The core elements of the LBA are the ATNF's three telescopes in New South Wales (Parkes, the Compact Array and Mopra); two telescopes of the University of Tasmania (the Hobart 26-m antenna in Tasmania and the Ceduna 30-m in South Australia); the Hartebeesthoek 26-m in South Africa; and the Warkworth 12-m and 30-m antennas in New Zealand. From time to time these have been augmented by the 70-m and 34-m antennas at the Canberra Deep Space Communications Complex at Tidbinbilla in the ACT, and the University of Tasmania's 12-m 'AuScope' antennas in Yarragadee, Western Australia, and Katherine in the Northern Territory. For a few years we have also sometimes used a single ASKAP antenna with a traditional 'single-pixel' feed.

This came to an end this year, as 30 ASKAP antennas have now been equipped with phased-array feeds.

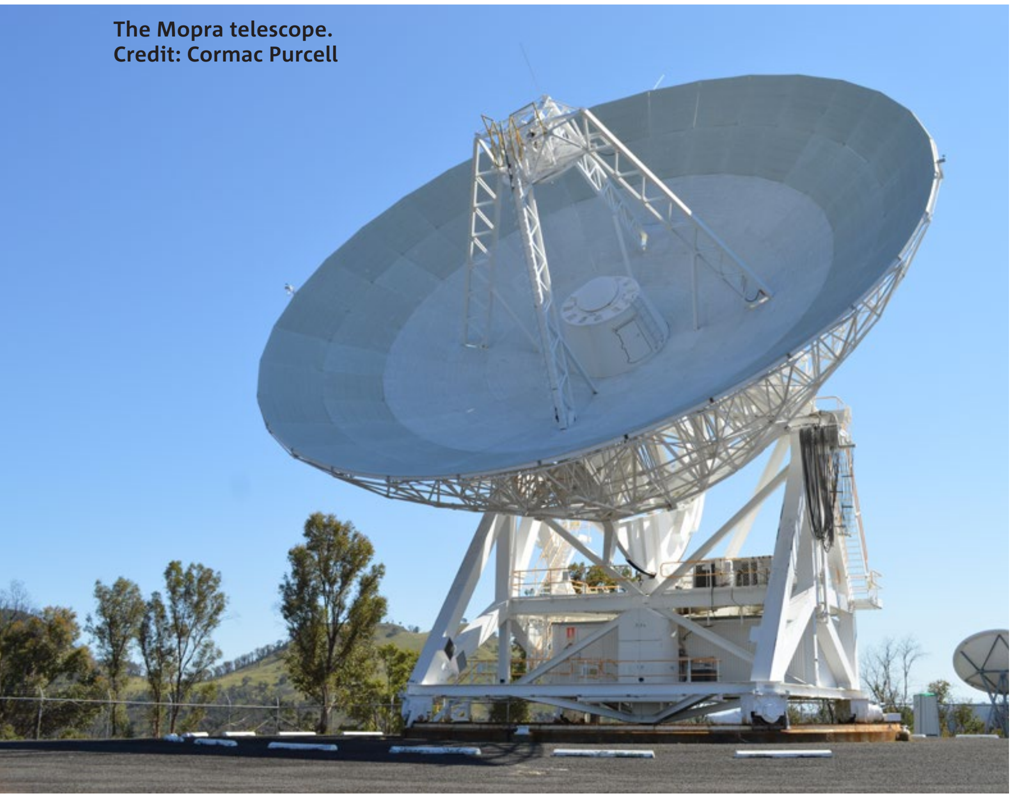
In 2016 there were 31 LBA experiments, involving nine Australian primary investigators (PIs) and 12 overseas PIs and using a total of 382 hours of observing time. The LBA was also kept busy with additional observations to support Russia's RadioAstron space VLBI mission. There were 65 RadioAstron survey experiments, usually for one hour each and involving at least one LBA antenna (typically three or four). There were also nine RadioAstron imaging experiments, which used a total of 78 hours' observing time. Most of the imaging experiments included telescopes from the USA, Asia and Europe.

All LBA experiments (other than the RadioAstron experiments) are correlated by ATNF staff using the DiFX software correlator. By early 2016 DiFX was ported to run on the Magnus supercomputer at the Pawsey supercomputing centre. This system has been running very smoothly, with a median time of 31 days between observation and release of data. The processing time is dominated by the time taken to transfer data (a median time of 22 days), largely because some stations do not have high-speed data networks and must post disk modules. A total of 306K hours of CPU time was used on Pawsey this year for LBA correlation.

In October we carried out the first-ever VLBI with two phased-array feeds (PAFs) – a notable technical achievement. A previous link-up with an ASKAP antenna had shown it was feasible to use a single PAF for VLBI. This year, a CSIRO phased-array feed was being commissioned on the Parkes 64-m telescope before delivery to the Max Planck Institute for Radioastronomy in Germany. During this commissioning, VLBI fringes were achieved using a single beam. The 'Parkes' firmware was installed in a single antenna at ASKAP and fringes were achieved between the Parkes and ASKAP PAFs. The technique developed in this experiment opens the way for multi-beam VLBI to be carried out, with the only limitation being disk arrays available to record the high data rates.

## Mopra

In 2016 Mopra was operated by a consortium of institutions led by the University of New South Wales. Under its agreement with CSIRO, the consortium covered all the costs for routine operations of the telescope (power, fuel for the generator, internet access, and routine maintenance). The consortium made some Mopra time available for Long Baseline Array observing during the year.


**The Mopra telescope. Credit: Cormac Purcell**

## Australian SKA Pathfinder (ASKAP)

The ASKAP (Australian SKA Pathfinder) project has seen an important transition this year, from BETA (the Boolardy Engineering Test Array) to ASKAP-12. BETA comprised six ASKAP antennas outfitted with the first generation of CSIRO phased-array feed receivers (PAFs); ASKAP-12 consists of 12 antennas equipped with second-generation PAFs.

BETA was a commissioning instrument. Its last act of service was a continuum survey at 711–1015 MHz of a 150 deg$^2$ field in the constellation of Tucana. Cycling the array through 12 interleaved pointing positions and using nine digitally formed beams mimicked a traditional 1 h x 108 pointing survey, covering the 150 deg$^2$ field in 12 hours of observing time. Three such observations were made over the course of a week, to investigate system stability and source variability.

The data from the three epochs was combined to form an image with arcminute resolution and a 1σ thermal noise level of 375 μJy beam$^{-1}$. The image contains 3,722 discrete radio components: the telescope's instantaneous bandwidth of 304 MHz (a fractional bandwidth of 35 per cent) made it possible to measure in-band spectral indices for 1,037 of them. The photometric accuracy and stability of the observations were checked by cross-matching the BETA sources with other surveys, principally SUMSS (the Sydney University Molonglo Sky Survey): the BETA observations came through with flying colours. This project clearly demonstrated the potential of the CSIRO PAFs for rapid broadband surveys. Details are published in Heywood *et al.* (MNRAS 457, 4160 (2016)).

Another of BETA's final contributions was a series of trials showing how phased-array feed receivers can mitigate radio-frequency interference (RFI) in a way not possible with traditional single-pixel feeds. For the tests, the ASKAP Commissioning and Early Science (ACES) team observed the radio calibrator source PKS 1934–638 at 1225 MHz, a frequency known to be affected by interference from GPS satellites. The technique relies on a PAF's ability to steer nulls. Details are outlined in a technical memo (Bannister, Hellbourg and Hotan 2016):
*www.atnf.csiro.au/projects/askap/aces_memo012.pdf*

BETA was retired early in 2016. In April, nine ASKAP antennas, fitted with second-generation PAFs, were used to image a field in Apus (the standard ASKAP test field) with 36 dual-polarisation beams: this was the first time so many phased-array feed beams had been used, anywhere. The observation was made over 11 hours, with 48 MHz of bandwidth centred at 939.5 MHz. The resulting continuum image was produced using ASKAP's dedicated imaging package, ASKAPsoft, running on the Galaxy supercomputer at the Pawsey Supercomputing Centre in Perth, WA. At 30 deg$^2$ the image was equivalent to ASKAP's full field of view, and contained more than 1,300 sources.

**An ASKAP image of the Apus field, made in April 2016. This continuum image was created using 36 beams and represents the full ASKAP field of view of 30 square degrees. (The moon is shown for comparison.) The image has an rms of about 300 microJansky/beam and contains more than 1300 sources. Credit: ASKAP team**

ASKAP Telescope Operating System version 2.8 and ASKAPsoft version 0.15 were released in October. At the same time, a full end-to-end software system test and verification was conducted successfully. The purpose of this procedure was to verify the entire data-flow of an ASKAP observation, from creation of the observing procedure (named Scheduling Block) to scheduling, acquisition, processing and deposition of the science data products in the CSIRO ASKAP Data Archive (CASDA) system.

Following this testing, ASKAP Early Science began in October with ASKAP-12, an array of 12 dishes fitted with second-generation PAFs. The first observations, conducted by the WALLABY team, targeted the nearby NGC 7232 galaxy group, and were aimed at mapping both the 21-cm H I line and radio continuum emission. The observations were made using interleaved square footprints, each with 6 x 6 (= 36) beams on the sky: this gave uniform noise over a 30 deg$^2$ field of view. Most of the data calibration and imaging has been done with the custom pipeline in *ASKAPsoft*, while source finding is done with *SoFiA*, the source-finding application developed by the WALLABY team. The field contains ~20 HIPASS sources, which help with quality checks and H I science verification. Four WALLABY fields were observed in 2016, for a total of just over 400 hours.

By the end of 2016, second-generation phased-array feeds (PAFs) had been installed on 30 ASKAP antennas and the ASKAP-12 array was taking data with a bandwidth of 192 MHz and all 36 beams. The ACES team expects to begin commissioning a 30-antenna array, ASKAP-30, in the third quarter of 2017.

**The solar array installed at the MRO in 2016 by Perth-based company Energy Made Clean (EMC). The array will be complemented by a 2.5 MWh battery system, and will supply a significant fraction of the observatory's power. Credit: Brett Hiscock**

## Spectrum management

Both radio telescopes and antennas of NASA's Deep Space Network use extremely sensitive radio receivers, and both radio astronomy and spacecraft communications are impeded by man-made radio-frequency interference (RFI). For these activities to continue, the frequency bands allocated to them need to be protected. More general 'spectrum management' is also increasingly important because new telescopes such as the Square Kilometre Array will attempt to access most of the radio spectrum.

At the international level, the radio spectrum is regulated by the International Telecommunication Union (ITU); the international treaty called the 'Radio Regulations' is updated every four years via the World Radiocommunication Conference (WRC). In Australia, spectrum regulation is handled by the Australian Communications and Media Authority (ACMA).

CSIRO strives to protect spectrum for both radio astronomy and space research. This requires a good working relationship with ACMA, the ITU and other regional and international forums, and with the Department of Defence and other major users of the radio spectrum. CSIRO also works to gain more specific protection for radio observatories and deep-space facilities. These efforts have led to the establishment of a 'Radio Quiet Zone' around the Murchison Radio-astronomy Observatory in Western Australia and 'Radio Notification Zones' around other radio observatories.

Highlights of this work in 2016 were:

- beginning a new round of studies for the next ITU-R World Radiocommunication Conference in 2019 (WRC2019). CSIRO is actively involved in ACMA processes to develop Australia's position for WRC agenda items, to ensure protection of radio astronomy and space research spectrum. It is also participating in ITU meetings preparatory to the WRC by developing studies relevant to the agenda items
- leading the ITU-R studies in ITU-R Working Party 7D (Radio Astronomy) and ITU-R Study Group 3 (Radiowave Propagation). CSIRO scientists chair both of these bodies, Tasso Tzioumis the Working Party and Carol Wilson the Study Group
- representing radio-astronomy and space research interests in the Department of Communications' review of the spectrum-management framework.

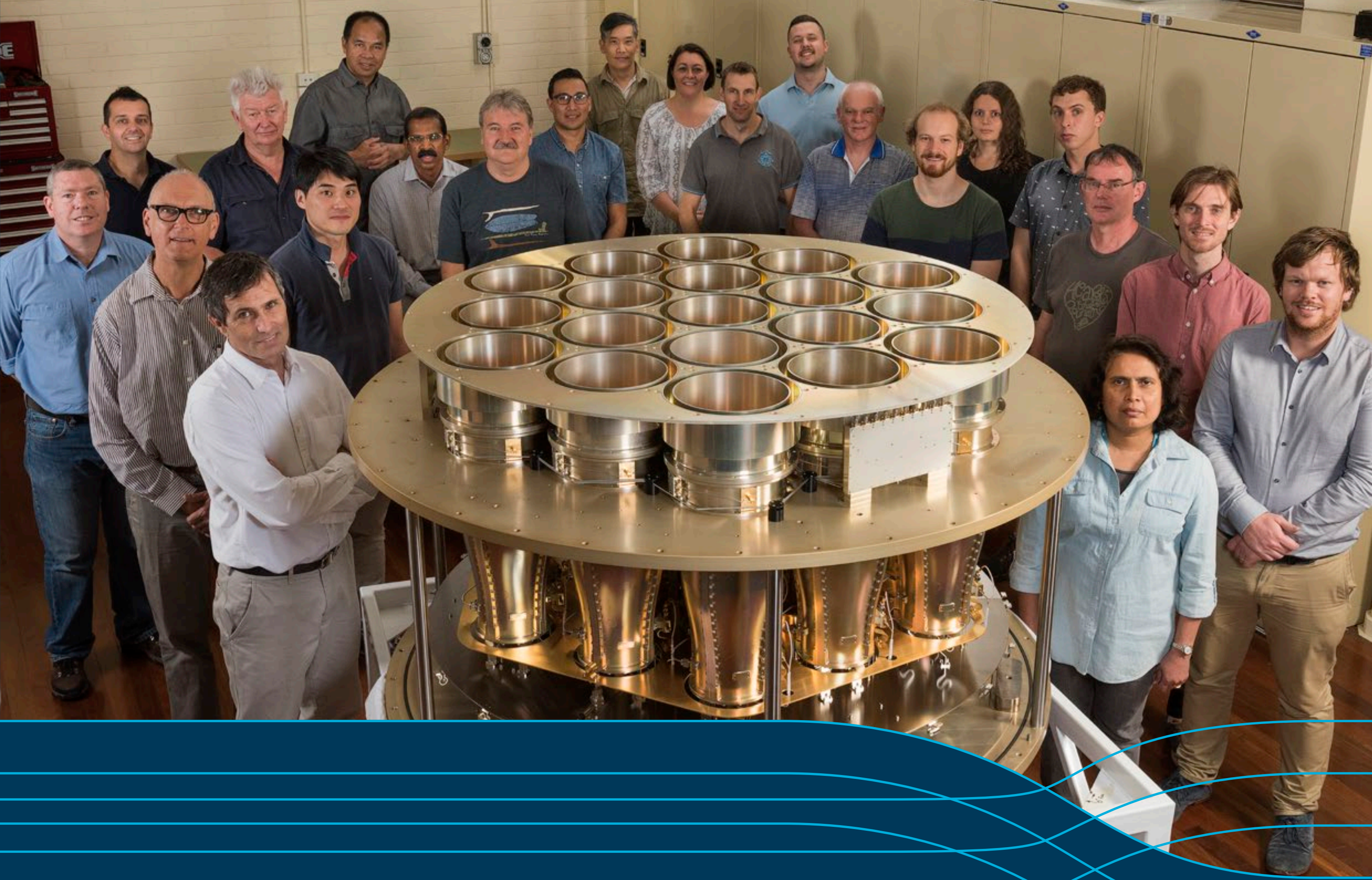
## Pulsar data storehouse promises future science

Observations with the Parkes telescope continue to lead to cutting-edge science discoveries, as Ravi *et al.*'s discovery and analysis of a new fast radio burst (page 21) shows. But the first fast radio burst (FRB) was found in archival Parkes data by Dr Duncan Lorimer (West Virginia University), when he was reprocessing them to look for individual pulses (Lorimer *et al.* 2007, Science, 318, 777). If this re-processing had not been carried out, or if the data had not been available, then perhaps FRBs would not be the key research topic for current and future radio telescopes that they now are.

Pulsar observations generate enormous volumes of data. Archiving those data is non-trivial; providing access to them is even harder. With funding from the Australian National Data Service, ATNF staff worked with a team from CSIRO Information Management and Technology (IM&T) to create the Parkes Pulsar Data Archive, which we launched in 2011. The archive (available from *data.csiro.au*) has grown rapidly: it now contains about 350 TB of data, and we expect to add about 200 TB a year from here on.

We have been exploring novel techniques for providing access to such datasets. In 2015 we won an *Astrocompute in the Cloud* grant, offered by the Square Kilometre Array Organisation and Amazon Web Services, to test processing of pulsar data in the Amazon Cloud: this year we showed that we could make the standard pulsar software packages available through Amazon and process different types of pulsar datasets. We have also tested new search algorithms on archived observations of the globular cluster 47 Tucanae, discovering two new pulsars (Pan *et al.* 2016, MNRAS, 459, 26).

Making large datasets available for the science community is a key challenge for the Square Kilometre Array (SKA) regional science centres, and our pulsar data archive is being used to demonstrate possible solutions. Making our data available to a wider community should also, we hope, lead to even more discoveries.



# Technology development

The FAST multibeam receiver during construction, with the CSIRO staff who designed and built it.
Credit: Wheeler Studios

# Technology development

## Parkes ultra-wideband receiver

Work continued this year on a new receiver for Parkes to cover the 0.7–4.2 GHz range. This new receiver will improve both the efficiency of single-beam observations and the sensitivity and precision of low-frequency observations.

The digital part of the system, designed by CSIRO, has been prototyped and tested in the laboratory. Together with the software system developed by Swinburne University, this will be installed and tested on the Parkes telescope in 2017. The low-noise amplifiers for the receiver, also designed by CSIRO, have been sent to a foundry for fabrication. Completion and commissioning of the full system at Parkes is planned for 2017.

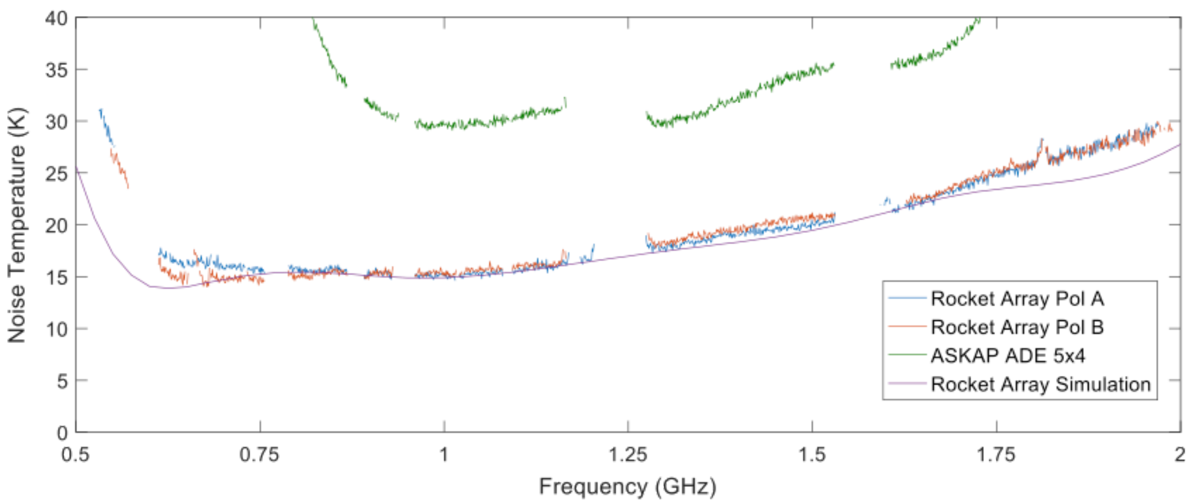
**The new rocket PAF prototype being lifted onto the Parkes 64-m telescope for tests in May. L-R: Douglas Hayman, Kanapathippillai Jeganathan, Alex Dunning (obscured), Wasim Raja and Ken Reeves. Credit: John Sarkissian**

## Phased-array feed technologies

The ATNF has considerable experience in phased-array feed (PAF) technologies, with two generations of the pioneering 'chequerboard' PAF employed very successfully, first in BETA (ASKAP's test array), and now in ASKAP proper. It is now leading a multinational consortium to continue research and development of PAFs, with a view to using them on the international Square Kilometre Array (SKA). The consortium, established as an SKA Advanced Instrumentation Program, comprises organisations from Australia, China, Germany, Italy, the Netherlands, Sweden and the UK, and is likely to be incorporated into the SKA's Observatory Development Program.

Early in the year the ATNF completed a PAF – a modified version of the second-generation PAFs for ASKAP – for the Max Planck Institute for Radioastronomy (MPIfR). Before being shipped to Germany this instrument was installed on the 64-m Parkes telescope for eight months (February to October) as part of its commissioning and testing, and used for key investigations including:

- a number of pulsar timing experiments, culminating in the first simultaneous timing of three pulsars in three separate PAF beams
- H I intensity mapping at 21 cm – spectral-line drift scans with 16 dual-polarisation beams. Observing the 21-cm lines of several known galaxies reproduced the expected spectra, with negligible baseline ripple. H I intensity mapping is a promising approach to constraining H I gas evolution at intermediate redshifts, and with their large fields of view PAFs offer the promise of doing it speedily
- searches for fast radio bursts (FRBs). This will be the PAF's main task when deployed on the MPIfR's 100-m Effelsberg telescope. The PAF's large field of view allows it to efficiently search a large area of sky for FRBs, while the dense sampling of the field at the reflector's focal plane will allow FRBs to be localised to much better than a beam width




**Measurements of the prototype rocket PAF (a 5 x 4 array) made in May 2016 at the Parkes aperture array testing facility. The performance of an earlier 5 x 4 test array for the ASKAP PAFs is shown for comparison.**

- VLBI (very long baseline interferometry). Good-quality fringes were achieved from the source 3C273 in VLBI observations between the PAF on Parkes and a PAF on an ASKAP antenna at the Murchison Radio-astronomy Observatory. This was the first demonstration of VLBI using two PAFs
- RFI Mitigation. Radio-frequency interference (RFI) was mitigated by applying subspace projection algorithms to the PAF's beamformer weights. Dominant terrestrial RFI was reduced by 20 dB to 30 dB when the dish was stationary.

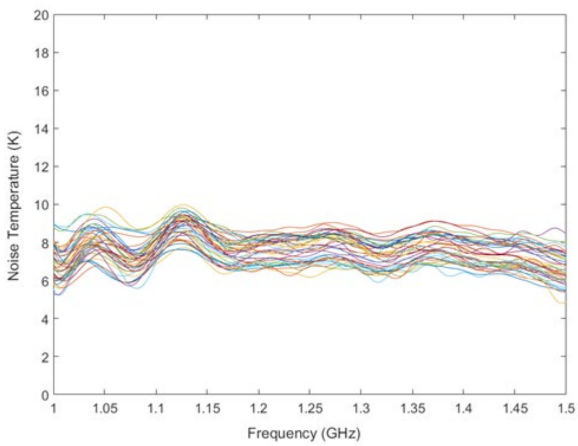
The MPIfR and CSIRO will collaborate on the deployment of the PAF on the Effelsberg telescope.

The ATNF is continuing to develop the next generation of PAF, the 'rocket PAF', a design with improved matching characteristics and superior performance. A small prototype rocket PAF was tested on the Parkes 64-m telescope this year. It performed better than the ASKAP PAFs under test at room temperature, and when installed on an ASKAP dish it is expected to have less spillover than the existing PAFs and to show an improvement of about 30 per cent. The ATNF has applied for funding to proceed with a cryogenically cooled version, which could be up to three times more sensitive, to use on the Parkes telescope.

## FAST 19-beam receiver

China's Five-hundred-meter Aperture Spherical radio Telescope, FAST, is the largest single-dish radio telescope in the world. Early in 2016 the National Astronomical Observatories of the Chinese Academy of Sciences contracted CSIRO to build a 19-beam receiver for FAST, based on the successful design of the multibeam receivers it had built for the Parkes and Arecibo telescopes.

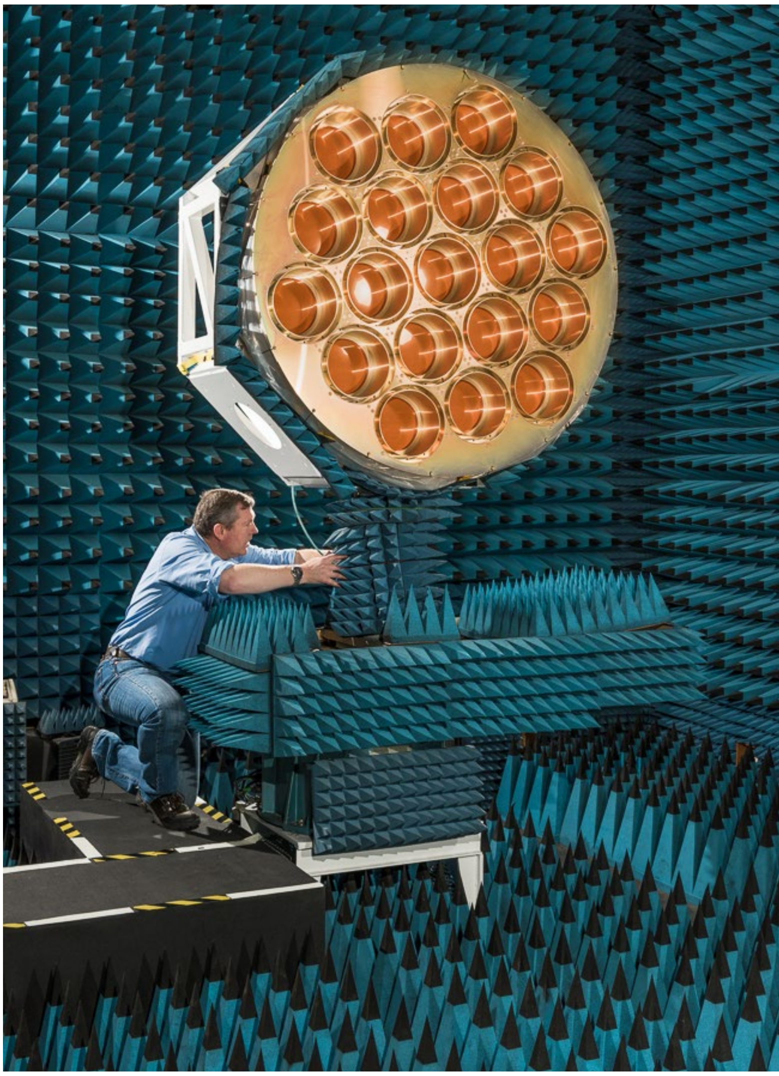
The cryogenically cooled 19-beam receiver is the largest and heaviest receiver CSIRO has ever tackled and a new laboratory had to be prepared for its construction. This year the ATNF completed the receiver's 19 feeds and orthomode transducer and measured their performance in the CSIRO antenna measurement range. The assembled system achieves an average noise temperature of 7.6 K. The receiver will be shipped to the FAST site in 2017.




**Flange noise temperature of the 38 receiver channels of the FAST 19-beam receiver, measured at the cryostat output.**

## Digital systems

This year the ATNF's Digital Systems group developed a new protocol for streaming data, CODIF, for next-generation radio-astronomy backends. CODIF was demonstrated with the backend for the phased-array feed (PAF) built by CSIRO for Germany's Max Planck Institute for Radioastronomy, which was commissioned and tested on the Parkes telescope this year. The Digital Systems group is also contributing actively to the development of the Square Kilometre Array, in the SKA.CSP Low.CBF project (page 37).



**Ken Smart (CSIRO Data61) with the receiver being built for China's FAST telescope. Photo: Wheeler Studios**

# Square Kilometre Array project

This year the international Square Kilometre Array (SKA) project continued to move closer to the construction of SKA phase 1, which will consist of two complementary SKA instruments:

- SKA1-Mid: 200 parabolic antennas in South Africa (including the 64 MeerKAT dishes)
- SKA1-Low: 130,000 low-frequency aperture-array (dipole) antennas in Australia.

CSIRO continued its involvement in the SKA project through seven of the 11 SKA R&D consortia, leading the Dish and the Infrastructure Australia consortia and present as a key partner in Assembly, Integration and Verification; Central Signal Processing; Signal and Data Transport; Science Data Processor; and Telescope Manager.

All SKA consortia have now passed their preliminary design reviews and are expected to go through their critical design reviews in 2017–2018.

Three rounds of negotiations were held this year to arrive at the details of the Inter-Governmental Organisation (IGO) treaty that will provide the framework for operating the SKA. CASS Deputy Director and SKA Leader Sarah Pearce represented CSIRO at these meetings. The treaty, which the partner countries expect to finalise in 2017, will bring into being the international SKA Observatory. Once established, the SKA Observatory's first act will be to approve the construction of SKA Phase 1. That in turn is expected to begin in 2018–2019.

CSIRO is to be the Australian Site Entity for the SKA, responsible for delivering radio quietness at the Murchison Radio-astronomy Observatory (MRO) and an Indigenous Land Use Agreement (ILUA), and for managing shared facilities such as roads and optical fibre.

To ensure that SKA1 is delivered under the defined cost cap of €674 million (2016 euros), in November the SKA Board directed the SKA Office to undertake a review of the existing design and to explore and capitalise on a range of cost-saving measures. This action includes drawing on cost-reduction options already identified and further exploiting potential cost-saving and risk-reduction technology developments and solutions provided by SKA precursor and pathfinder facilities. The SKA Office will present preliminary recommendations to the March 2017 meeting of the Board.

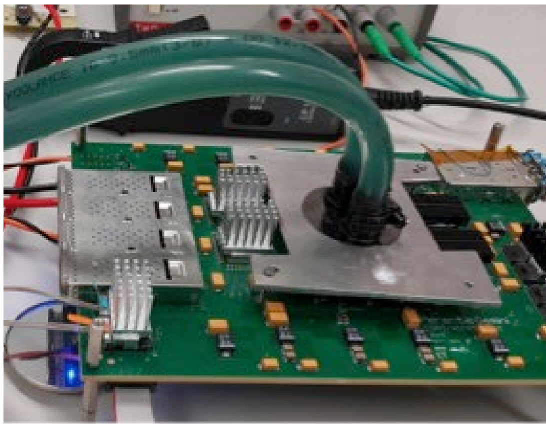
The annual SKA Engineering meeting was held in Stellenbosch, South Africa, in October, with the science meeting, *Science for the SKA Generation*, held in Goa, India, in November. The ATNF was well represented at both meetings.

**Representatives from SKA member countries during the third round of negotiations to constitute the SKA Organisation (SKA) as an intergovernmental organisation. The discussions were held in Rome during 19–21 April. Credit: SKAO**

## Instrumentation

Within the Central Signal Processing (CSP) consortium, CSIRO also leads the sub-element team designing the correlator and beamformer for SKA1-Low. This team is a collaboration between CSIRO, ASTRON in the Netherlands (a group led by Andre Gunst) and Auckland University of Technology (Peter Baillie and David Wilson). During the year, CSP members Andrew Brown (ATNF) and Gijs Schoonderbeek (ASTRON) combined their design talents to produce the first prototype hardware for the beamformer and correlator for SKA-Low. It comprises a single FPGA card (water cooled), a twelve slot chassis for same, plus ancillary heat exchangers, and control servers and switches. The prototype was developed mainly to test the performance of the latest field-programmable gate array (FPGA) technology and emerging high-speed memory devices. To accelerate the design, Andrew travelled to the ASTRON labs in the Netherlands for a three-month intense development period.

In June, the Compact Array was used to successfully verify a prototype of the SKA's frequency synchronisation system, which coordinates the collection of data from widely separated antennas. Built by ICRAR–UWA in partnership with the SKA's Signal and Data Transport consortium, the prototype continuously measures the changes in the optical fibre that links the network of antennas and applies a correction in real time, reducing fluctuations to no more than one part in ten trillion over a 1-second period – a level of performance 10 to 100 times better than required for the SKA.



**The first prototype hardware for the beamformer and correlator for SKA-Low. Credit: Grant Hampson**

# People and community

Karen Lee-Waddell (ATNF) leading solar viewing at Pia Wadjarri Remote Community School in WA.

Credit: Rob Hollow

# People and community

## Astronomical community

### INPUT FROM THE COMMUNITY

The users of ATNF telescopes contribute to ATNF decision-making through an advisory group, the Australia Telescope User Committee (ATUC), the members of which are listed in Appendix A. ATUC considers current operations, priorities for future developments, and other matters raised by the user community, then makes recommendations to the ATNF Director: most recommendations are accepted and implemented. This year ATUC met in June and November. Its reports to the ATNF Director,
and the Director's replies, can be found at *www.atnf.csiro.au/management/atuc/index.html*.

### MEETINGS, WORKSHOPS AND COLLOQUIA

In 2016 the ATNF hosted a number of meetings and workshops for the benefit of the astronomical community:

#### ASKAP 'busy weeks'

During the year the ASKAP Commissioning and Early Science (ACES) team hosted five ASKAP 'busy weeks' (multi-day meetings for focused discussion and problem solving). The first (8–10 March, at CSIRO Marsfield) was for the ACES team alone. The following four were 'community' events attended by 17–29 people, about half of whom were non-CSIRO: these were held at CSIRO Marsfield (10–12 May), CSIRO Perth (26–28 April), The University of Sydney (29–31 March), and The Australian National University (29 Nov–1 Dec). Participants learned about aspects of handling ASKAP data including the ASKAP data-reduction pipelines, accessing and using the Pawsey supercomputer, and the CSIRO ASKAP Science Data Archive (CASDA).

#### ATNF Data Reduction Workshop 2016

(Sydney, 2–6 May)

At this hands-on workshop ATNF staff mentored users of ATNF telescopes, helping them make progress with their data reduction.

#### ASKAP 2016: The Future of Radio Astronomy Surveys

(Sydney, 6–10 June)

This event, for future users of ASKAP, discussed future strategies for observing and sharing data from large astronomical surveys.

#### The First Pietro Baracchi Conference: Italo-Australian Radio Astronomy in the Era of the SKA

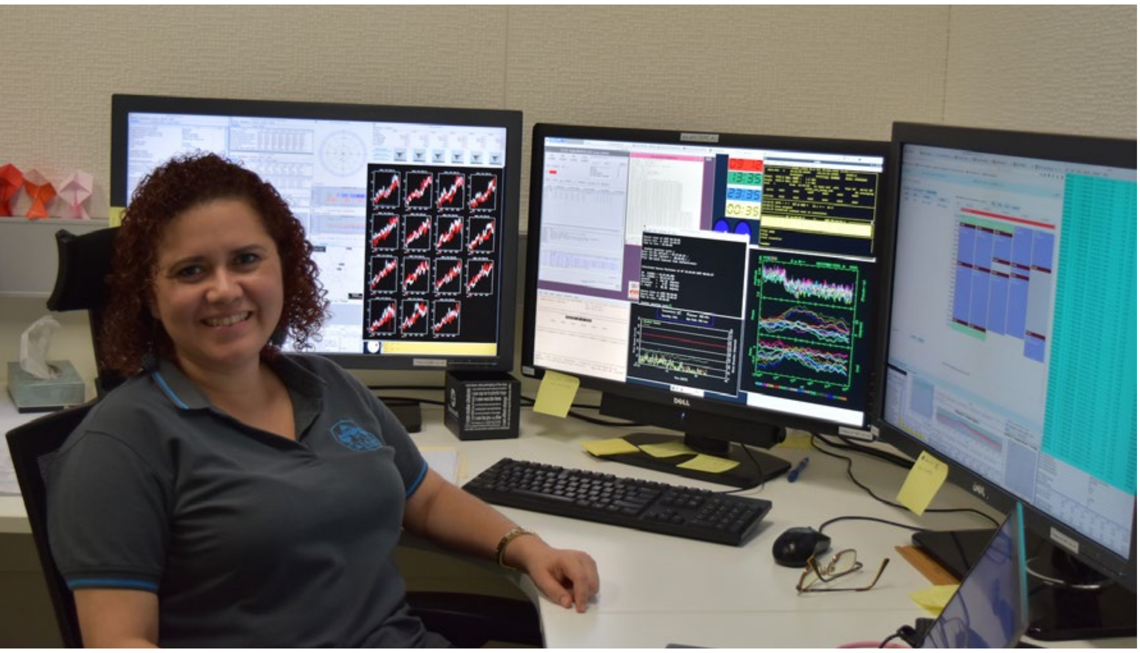
(Perth, 1–4 November)

This conference, the first of a planned series to be held alternately in Australia and Italy, brought together researchers from both countries to discuss their significant and growing connections in radio astronomy.

#### 3D Visualisation Workshop

(Sydney, 16–18 November)

This international workshop brought together experts from a range of fields (including astronomy, biology, nanotechnologies and earth sciences) to explore tools for making and using 3D visualisations of large datasets.



**Lucero Uscanga (University of Guanajuato, Mexico) observing with the Compact Array from the ATNF Science Operations Centre in Sydney. Credit: Gulay Gurkan Uygun**

### 2016 Bolton and Student Symposium

(Perth, 22 November)

This annual event showcased work carried out with Australian facilities.

A number of ATNF staff also attended:

### A Celebration: Bruce Slee and 70 Years of Radio Astronomy

(16–17 August)

This workshop, held at the University of Sydney, covered the wide-ranging contributions of pioneering CSIRO radio astronomer Bruce Slee.

### Innovation and Discovery in Radio Astronomy – A Celebration of the Career of Ron Ekers

(13–17 September)

This meeting, held in Queenstown, New Zealand, highlighted the contributions of ATNF's founding director, CSIRO Fellow Ron Ekers, to radio astronomy.

In addition, at its Marsfield headquarters the ATNF runs a program of regular colloquia, usually given by researchers visiting from other countries or other parts of Australia. Thirty-nine (39) talks were given this year.

# Outreach and education

## VISITORS CENTRES

In 2016 the Visitors Centre at the Parkes observatory attracted 87,471 visitors, a number essentially the same as in 2015 (87,139). The number of students and teachers fell slightly to 1,304 (from 1,396 in 2015), while the number of tour-group visitors rose to 2,376 (from 1,636 in 2015).

This year the Compact Array received 11,223 visitors: again, this number was little changed from 2015 (11,316).

## OUTREACH

CASS staff contributed to the following key outreach events in 2016:

### Science Awareness Festival, Geraldton

This event, held on 30–31 March, was an opportunity for high-school students to learn about the importance of science, technology, engineering and maths both in everyday life and for many careers. We ran a 10-hour marathon PULSE@Parkes session for school groups, a teacher workshop and the public evening session.

### Perth Astrofest

This year's event, held on 12 March at Curtin University, attracted more than 4,500 people for astronomy talks, exhibits and sky viewing. The CASS/SKA booth was busy as ever with Lego antenna building for the children and the opportunity to talk with our astronomers and engineers.

**Astronomers at Science Meets Parliament, 1–2 March 2016. This annual event allows scientists to talk directly with members of the Australian Parliament. L-R: Alex Dunning (ATNF), Vanessa Moss (University of Sydney), Brent Groves (Australian National University), Karen Lee-Waddell (ATNF) and Lee Spitler (Macquarie University). Credit: Mark Graham, Science meets Parliament 2016.**

### PULSE@Parkes in China

This program allows school students to observe with the Parkes telescope. The year's regular sessions were capped off by a number in Guangzhou, China, during 11–16 November. CASS staff Rob Hollow, Shi Dai, George Hobbs and George's PhD student Zhang Lei ran PULSE@Parkes sessions for more than 90 students, from ten high schools, and also gave talks to more than 500 high-school and university students. This was a return visit: the first trip to Guangzhou, also very successful, took place in 2015.

### Outreach to Pia school

CASS staff (Karen Lee-Waddell, Craig Anderson, Rob Hollow and Leonie Boddington) visited the Pia Wadjarri Remote Community School near the Murchison Radio-astronomy Observatory (MRO) on 19 October to run a day of astronomy activities with the students. The following day the students visited the MRO for a tour of ASKAP.

### Teacher Workshops

Sessions were held at a number of science-teacher conferences and events across Australia. A highlight was a PULSE@Parkes hands-on session for teachers at CONASTA, the national science teacher conference, in Brisbane in July.

## MEDIA RELEASES

In 2016 CSIRO issued seven media releases related to the ATNF:

*Dark 'noodles' may lurk in the Milky Way*
(21 January)

*Solved! First distance to a fast radio burst*
(25 February)

*Australian technology behind the world's largest telescope*
(5 May)

*Parkes telescope detects key feature of life outside our solar system*
(15 June)

*Search for ET underway with CSIRO's Parkes radio telescope*
(8 November 2016)

*Galaxies sail on a tranquil sea, cosmic flash shows*
(18 November)

*Cool theory on galaxy formation (2 December).*

**Students Katherine James (Rhodes University) and Tokiso Motoai (University of the Free State) visited CASS in 2016 on an undergraduate program created by CASS and SKA South Africa. Credit: Rob Hollow**

## CASS AND CASS/SKA SOUTH AFRICA UNDERGRADUATE VACATION SCHOLARSHIP PROGRAMS

The 2016–2017 CASS Undergraduate Vacation Scholarship program included ten students from around Australia working on research projects for ten weeks over summer. For the first time we had four students based in our Perth office; the rest were in Marsfield. All of the students visited the Compact Array in January for hands-on observing projects and presented their individual projects at the Student Symposium in February.

A new initiative saw us visited by two students from South Africa, Katherine James and Tokiso Motoai, who came on an undergraduate scholarship program created by CASS and SKA South Africa. They worked alongside the other CASS undergraduate scholars, carrying out research projects on machine learning for ASKAP and pulsar observing. This work will promote synergies between Parkes and South Africa's MeerKAT telescope.

# Staff

## STAFFING LEVELS

CASS's Perth office grew to 14 staff by the year's end. Total ATNF staff levels decreased slightly, as cessations exceeded recruitment. Thirty-three staff ceased employment in 2016 as a result of resignation (11), retirement (6), term employment ending (15) and redundancy (1). In November, Acting ATNF Director Dr Douglas Bock, formerly Program Director for ATNF Operations, was appointed as ATNF Director and Director of CSIRO Astronomy and Space Science.

## DIVERSITY

The major undertaking of the CASS Diversity Committee this year was conducting the CASS diversity survey. This confidential and externally evaluated survey investigated staff experiences across the diversity and equity spectrum. A complementary CSIRO-wide culture survey was made at the same time, allowing us to compare the wellbeing of CASS staff with that of staff in other areas of CSIRO. An all-staff briefing discussing the outcomes was held in October. The outcomes of the culture survey have provided (and will continue to provide) focus for the Diversity Committee. In many areas, the respondents to the diversity survey felt CASS provided a positive environment. In particular, respondents felt they had good relationships with their co-workers, that they were valued and respected, and that CASS supports an inclusive culture. However, the survey highlighted areas in which CASS could make improvements. For example, there are disparities in satisfaction between CASS sites, and higher levels of dissatisfaction and unhappiness in underrepresented groups. The awareness of the Diversity Committee varied between the sites, being highest at the Marsfield headquarters. One of the priorities for the committee in 2017 will be to engage more with staff, particularly at sites other than Marsfield.

In November, ABC Radio National's *Background Briefing* series broadcast a program on alleged cases of misconduct (including alleged cases of bullying, sexual harassment and sexual assault) at CASS. The committee takes these allegations very seriously and in the next year, the committee will work to ensure CASS is safe place for all to work, study, and visit.

We thank Jill Rathborne for leading the committee for the past three years. Jill has left CASS to take a position with the Australian Academy of Science's SAGE program, which is investigating gender equity in science across Australia. We are sad to see Jill leave, but look forward to continuing to work with her in this domain.

## AWARDS

In October Dr Lisa Harvey-Smith, a member of the ATNF Astrophysics group, was awarded the *Department of Industry, Innovation and Science Eureka Prize for Promoting Understanding of Australian Science Research*. The annual Eureka Awards, managed by the Australian Museum, are among Australia's most prestigious for scientific research and activities that support it. Lisa, who had also been a finalist in 2015, was recognised for her outstanding record in public engagement, particularly with girls and indigenous students – online, in the media and with live audiences.


**Lisa Harvey-Smith speaking at the 2016 Eureka Awards. Credit: Chrissie Goldrick**

**Jayde Clayton, a member of the ATNF Visitor Services Group. Credit: Leonie Boddington**

## HEALTH, SAFETY AND ENVIRONMENT

This year ATNF staff reported no lost-time injuries (LTI) and only two injuries requiring medical treatment (MTI): a musculoskeletal injury arising from an extended period of driving and an insect bite.

**TABLE 1. ATNF HEALTH, SAFETY AND ENVIRONMENT INCIDENTS, 2012–2016.**

| PERIOD | E INCIDENTS | H&S INCIDENTS* | LTI | MTI |
|---|---|---|---|---|
| Jan–Dec 2012 | 0 | 16 | 4 | 3 |
| Jan–Dec 2013 | 1 | 10 | 1 | 3 |
| Jan–Dec 2014 | 1 | 14 | 1 | 0 |
| Jan–Dec 2015 | 2 | 4 | 3 | 2 |
| Jan–Dec 2016 | 0 | 12 | 0 | 2 |

E = environmental; H&S = health and safety; LTI = lost-time injuries (injuries that resulted in the loss of one or more whole days after the date of the injury); MTI = medical-treatment injury (an injury requiring medical treatment other than first-aid). *Injuries only (not inclusive of hazards and near miss incidents). Note: the corresponding table in the 2015 ATNF annual report was incorrectly labelled as CASS HSE incidents.

**TABLE 2. BREAKDOWN OF ATNF HEALTH AND SAFETY INCIDENTS 2016**

| | |
|---|---|
| Musculoskeletal strain | 4 |
| Eye injury | 1 |
| Fume exposure | 2 |
| Laceration | 2 |
| Slip trip fall | 3 |
| Total | 12 |

Training sessions saw a big increase in attendance this year: 125 person-sessions were recorded, well up on the 53 in 2015.

**TABLE 3. CASS HEALTH AND SAFETY TRAINING SESSIONS 2016.**

| TOPIC | COURSE | COUNT |
|---|---|---|
| Chemical awareness | GHS Awareness | 11 |
| First aid | Provide First Aid Refresher Course | 1 |
| | Advanced Resuscitation | 7 |
| | Remote Area First Aid | 31 |
| Induction/refresher | Starting with Your Safety | 30 |
| Investigation | Supervisor Investigation Awareness | 2 |
| Laser safety | Laser Safety Training | 7 |
| Manual Handling | Move4Life | 4 |
| | MSD – Overuse Prevention Awareness | 8 |
| Psycho social | Mental Health Awareness for Managers | 3 |
| | Preventing Bullying and Harassment | 21 |
| **Total** | | 125 |

In 2012 the ATNF conducted a detailed HSE review of the issues related to driving 4WD vehicles on unpaved roads. This led to a number of recommendations on training, fatigue and journey preparation that are particularly relevant for staff travelling to and from the Murchison Radio-astronomy Observatory. In 2016, two more staff (Balthasar Indermuehle and Robert Ryan) received 4WD training in Western Australia. Note: the corresponding table in the 2015 ATNF annual report was incorrectly labelled as ATNF health and safety training sessions.

## ATNF management team

**ATNF DIRECTOR AND DIRECTOR CSIRO ASTRONOMY AND SPACE SCIENCE**

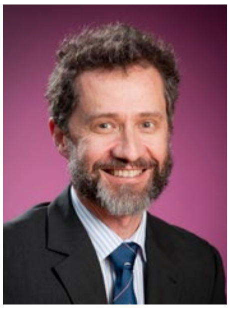
Douglas Bock*

**DEPUTY DIRECTOR**

Sarah Pearce

**FACILITIES PROGRAM DIRECTOR, OPERATIONS**

John Reynolds



**FACILITIES PROGRAM DIRECTOR, ASKAP**

Antony Schinckel

**FACILITIES PROGRAM DIRECTOR, ENGINEERING**

Tasso Tzioumis

**FACILITIES PROGRAM DIRECTOR, ASTROPHYSICS**

Simon Johnston**

**STRATEGIC PLANNING AND MAJOR PROJECT SPECIALIST**

Phil Crosby

**RESEARCH OPERATIONS MANAGER**

Warren Bax

* Lewis Ball was ATNF Director until 17 March 2016. Douglas Bock was Acting Director from 18 March until appointed as Director on 10 November.
** Ian Heywood acted as Facilities Program Director, Astrophysics, from 7 July to 19 September, and then again from 28 November into 2017.


# Appendices

Wildflowers at the
Murchison Radio-astronomy Observatory.

Credit: Cornelia Brem

# A: Committee membership

## ATNF Steering Committee in 2016

### CHAIR

Dr Susan Barrell, Bureau of Meteorology

### EX-OFFICIO

Dr Dave Williams, Executive Director, CSIRO Digital, National Facilities and Collections

Mr Brendan Dalton, Chief Information Officer, CSIRO

Professor Warrick Couch, Director, Australian Astronomical Observatory

### AUSTRALIAN-BASED ASTRONOMERS

Professor Stuart Wyithe, University of Melbourne

Professor Mark Wardle, Macquarie University

Professor Elaine Sadler, University of Sydney

### INTERNATIONAL ASTRONOMICAL COMMUNITY

Professor Grazia Umana, INAF Catania Astrophysical Observatory

Professor Neal Evans, University of Texas, Austin, USA

Professor Na Wang, Xinjiang Astronomical Observatory, China

### AUSTRALIAN STAKEHOLDER COMMUNITIES

Dr Susan Barrell, Bureau of Meteorology, Australia

Professor Robyn Owens, University of Western Australia

## Australia Telescope User Committee in 2016

### CHAIR

Associate Professor Virginia Kilborn, Swinburne University of Technology (2014–2017)

### SECRETARY

Dr Joanne Dawson, Macquarie University and CSIRO Astronomy and Space Science (Nov 2014–Jun 2017)

### MEMBERS

Dr Stuart Ryder, Australian Astronomical Observatory (Nov 2015–Jun 2018)

Dr James Miller-Jones, Curtin University (Nov 2014–Jun 2017)

Dr Vanessa Moss, University of Sydney (Nov 2015–Jun 2018)

Dr Paolo Serra, CSIRO Astronomy and Space Science (Nov 2014–Jun 2017)

Dr Stas Shabala, University of Tasmania (Nov 2014–Jun 2017)

Dr Willem van Straten, Swinburne University (Nov 2015–Jun 2018)

Ms Katharina Lutz (Jun 2016–Nov 2016)

Mr Daniel Reardon, Monash University (Nov 2016–Jun 2017)

The Australia Telescope Steering Committee appoints the members of the Australia Telescope User Committee (ATUC). New ATUC members usually start their three-year term with the November meeting in their first year and finish their term after the June meeting in their last year. Students are usually appointed for one year (two meetings). Dates of the first and last meetings are given.

## Australia Telescope Time Assignment Committee

(as of December 2016)

### CHAIR

Professor Sarah Maddison, Swinburne University of Technology

### EX-OFFICIO

Dr Douglas Bock, Astronomy and Space Science (Director, ATNF)

Dr Philip Edwards, CSIRO Astronomy and Space Science (Head of Science Operations)

Dr Jill Rathborne, CSIRO Astronomy and Space Science (TAC Executive Officer)

### VOTING MEMBERS

Dr James Allison, CSIRO Astronomy and Space Science

Dr Hayley Bignall, CSIRO Astronomy and Space Science

Dr Julia Bryant, Australian Astronomical Observatory and The University of Sydney

Dr Joanne Dawson, Macquarie University and CSIRO Astronomy and Space Science

Dr Alan Duffy, Swinburne University of Technology

Professor Sarah Maddison, Swinburne University of Technology

Dr Roberto Soria, Curtin University

Dr Ryan Shannon, Curtin University and CSIRO Astronomy and Space Science

Dr Ivy Wong, University of Western Australia

### ADMINISTRATIVE SUPPORT

Amanda Gray, CSIRO Astronomy and Space Science

# B: Financial summary

The table below summarises the revenue and expenditure applied to CSIRO's radio astronomy activities.

| | YEAR TO 30 JUNE 2011 | YEAR TO 30 JUNE 2012 | YEAR TO 30 JUNE 2013 | YEAR TO 30 JUNE 2014 | YEAR TO 30 JUNE 2015 | YEAR TO 30 JUNE 2016 |
|---|---|---|---|---|---|---|
| | (A$'000) | (A$'000) | (A$'000) | (A$'000) | (A$'000) | (A$'000) |
| Revenue | | | | | | |
| External | 7,181 | 13,726 | 4,213 | 10,179 | 13,209 | 14,377 |
| Appropriation[1, 2] | 36,419 | 35,623 | 35,668 | 41,803 | 42,966 | 42,094 |
| Total revenue | 43,600 | 49,349 | 39,881 | 51,982 | 56,175 | 56,470 |
| | | | | | | |
| Expenses | | | | | | |
| Salaries | 14,046 | 14,884 | 16,688 | 17,723 | 19,545 | 21,179 |
| Travel [3] | 1,080 | 1,093 | 1,432 | 1,325 | 1,429 | 1,981 |
| Other operating | 5,028 | 5,081 | 5,143 | 7,157 | 8,134 | 8,837 |
| Overheads [4] | 12,914 | 13,055 | 12,725 | 14,709 | 14,506 | 13,711 |
| Corporate support services | 0 | 0 | 0 | 0 | 0 | |
| Depreciation and amortisation | 3,953 | 4,081 | 4,628 | 7,095 | 7,513 | 10,101 |
| Doubtful debt expense | 0 | 0 | 0 | 0 | 0 | 0 |
| Total expenses | 37,021 | 38,194 | 40,616 | 48,009 | 51,127 | 55,809 |
| Profit/(Loss) on sale of assets | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | |
| Operating result [5] | 6,579 | 11,155 | – 735 | 3,973 | 5,047 | 662 |

**NOTES**

1. Increases in appropriation funding have been provided to fund increased depreciation and overheads. The increased depreciation is a result of ASKAP construction.

2. Included within appropriation funding to cover direct costs (A$'000):

| 2014 | 2015 | 2016 |
|---|---|---|
| 22,323 | 18,454 | 18,282 |

3. The increase in travel and operating costs in 2015–2016 reflects additional activity as a result of ASKAP commissioning and involvement in SKA consortia.

4. Overheads include corporate support services and business-unit support services.

5. The operating surplus in 2014 and 2015 is largely a result of actual depreciation costs being lower than forecast.

# C: Staff list

**ALL STAFF WHO WORKED FOR CASS ON RADIO-ASTRONOMY RELATED ACTIVITIES, AS OF DECEMBER 2015**

This list includes casual staff and honorary fellows, but not students or contractors.

| MARSFIELD | | |
|---|---|---|
| Allen | Graham | Project Specialist |
| Allison | James | Astrophysics |
| Amy | Shaun | Operations |
| Annuscheit | Aaron | Astrophysics |
| Bannister | Keith | Engineering |
| Baquiran | Mia | Engineering |
| Barker | Stephen | Engineering |
| Bax | Warren | Finance |
| Bell | Martin | Astrophysics |
| Beresford | Ronald | Engineering |
| Bock | Douglas | Director |
| Bourne | Michael | Engineering |
| Bowen | Mark | Engineering |
| Broadhurst | Steven | Engineering |
| Brothers | Michael | Engineering |
| Brown | Andrew | Engineering |
| Bunton | John | Engineering |
| Burns | Kelburn | Engineering |
| Castillo | Santiago | Engineering |
| Chapman | Jessica | Fellow |
| Chekkala | Raja | Engineering |
| Chen | Yuqing | Engineering |
| Cheng | Wanxiang | Engineering |
| Chippendale | Aaron | Engineering |
| Chow | Kate | Project Specialist |
| Chung | Yoon | Engineering |
| Clayton | Jayde | Operations |
| Cooper | Adam | Engineering |
| Cooper | Paul | Engineering |
| Cosma | Morgan | Engineering |
| Craig | Daniel | Operations |
| Crosby | Philip | Business Strategy |
| D'Amico | Oscar | Engineering |
| D'Costa | Howard | Project Specialist |
| Dai | Shi | Astrophysics |
| Death | Michael | Engineering |
| Denes | Helga | Astrophysics |
| Doherty | Paul | Engineering |
| Drazenovic | Victoria | Operations |
| Dunning | Alexander | Engineering |
| Edwards | Leanne | Operations |
| Edwards | Philip | Operations |
| Ekers | Ronald | Fellow |
| Ferris | Richard | Fellow |
| George | Daniel | Engineering |
| Gough | Russell | Fellow |
| Gray | Amanda | Administration |
| Green | James | Operations |
| Hampson | Grant | Engineering |
| Hartmann | Carmel | Administration |
| Harvey-Smith | Lisa | Operations |
| Hayes | Michael | Project Specialist |
| Hayes | Allison | Operations |
| Hayman | Douglas | Engineering |
| Heywood | Ian | Astrophysics |
| Hobbs | George | Astrophysics |
| Hollow | Robert | Education and Outreach |
| Huynh | The | Engineering |
| Indermuehle | Balthasar | Operations |
| Jeganathan | Kanapathippillai | Engineering |
| Johnston | Simon | Astrophysics |
| Kachwalla | Elsa | Operations |
| Kanoniuk | Henry | Engineering |
| Kesteven | Michael | Fellow |
| Kiraly | Dezso | Engineering |
| Koribalski | Barbel | Astrophysics |
| Kosmynin | Arkadi | Operations |
| Largent | Marcia | Health, Safety and Environment |
| Leach | Mark | Engineering |
| Lee-Waddell | Karen | Astrophysics |
| Lennon | Brett | Operations |
| Li | Li | Engineering |
| Lim | Boon | Engineering |
| Mackay | Simon | Engineering |
| Macleod | Adam | Project Specialist |
| Madrid Gamboa | Juan | Astrophysics |
| Maher | Anthony | Operations |
| Manchester | Richard | Fellow |
| Marquarding | Malte | Operations |
| Marvil | Joshua | Astrophysics |
| Matthews | John | Engineering |

| | | |
|---|---|---|
| McConnell | David | Operations |
| McDonald | William | Engineering |
| McIntyre | Vincent | Operations |
| Mitchell | Daniel | Operations |
| Moncay | Ramoncito | Engineering |
| Ng | Andrew | Project Specialist |
| Norris | Raymond | Fellow |
| Ord | Stephen | Operations |
| Owens | Robyn | Administration |
| Pearce | Sarah | Deputy Director |
| Peiris | Hyacinth | Engineering |
| Phillips | Christopher | Operations |
| Pilawa | Michael | Engineering |
| Pope | Nathan | Operations |
| Raja | Wasim | Operations |
| Reilly | Leslie | Engineering |
| Reynolds | John | Operations |
| Rispler | Adrian | Project Specialist |
| Roberts | Paul | Engineering |
| Roush | Peter | Engineering |
| Schinckel | Antony | Project Specialist |
| Severs | Sean | Engineering |
| Shannon | Ryan | Astrophysics |
| Shao | Li | Astrophysics |
| Shaw | Robert | Engineering |
| Shields | Matthew | Project Specialist |
| Smith | Stephanie | Engineering |
| Soo | Susan | Administration |
| Stopford | Susan | Administration |
| Storey | Michelle | Project Specialist |
| Stuart | Wayne | Engineering |
| Svenson | Nicola | Project Specialist |
| Tam | Kam | Operations |
| Tesoriero | Julie | Administration |
| Toomey | Lawrence | Astrophysics |
| Troup | Euan | Operations |
| Tuthill | John | Engineering |
| Tzioumis | Anastasios | Engineering |
| Venables | Veronica-Claire | Engineering |
| Voronkov | Maxim | Operations |
| Wang | Jing | Astrophysics |
| Wark | Robin | Operations |
| Whiting | Matthew | Operations |
| Wieringa | Mark | Operations |
| Wilson | Carol | Engineering |
| Wilson | Warwick | Fellow |
| Wright | Andrew | Human Resources |
| Wu | Xinyu | Operations |
| **NARRABRI** | | |
| Bateman | John | Operations |
| Cole | James | Operations |
| Forbes | Kylee | Operations |
| George | Michael | Operations |
| Hill | Michael | Operations |
| Kelly | Pamela | Operations |
| McFee | Margaret | Operations |
| McFee | John | Operations |
| Mirtschin | Peter | Operations |
| Rex | Jordan | Operations |
| Stevens | Jamie | Operations |
| Sunderland | Graeme | Operations |
| Tough | Bruce | Operations |
| Wilson | Christine | Operations |
| Wilson | John | Operations |
| Wilson | Tim | Operations |
| **PARKES** | | |
| Abbey | Alexander | Operations |
| Crocker | Jonathan | Operations |
| Hoyle | Simon | Operations |
| Hunt | Andrew | Fellow |
| Kaletsch | Robert | Operations |
| Kinsela | Leonie | Operations |
| Lees | Ronald | Operations |
| Lensson | Erik | Fellow |
| Mader | Stacy | Operations |
| Marshall | Margaret | Operations |
| Milgate | Lynette | Operations |
| Preisig | Brett | Operations |
| Reeves | Kenneth | Operations |
| Ruckley | Timothy | Operations |
| Sarkissian | Markarid | Operations |
| Sarkissian | John | Operations |
| Smith | Malcolm | Operations |
| Trim | Tricia | Operations |
| Unger | Karin | Operations |
| Veale | Roxanne | Operations |

| GERALDTON | | |
|---|---|---|
| Boddington | Leonie | Operations |
| Cox | Thomas | Operations |
| Desmond | Rochelle | Operations |
| Dunn | Peter | Operations |
| Hannah | James | Operations |
| Harding | Alexander | Operations |
| Hathway | Stephen | Operations |
| Hiscock | Brett | Operations |
| Jackson | Suzanne | Operations |
| McConigley | Ryan | Operations |
| Morris | John | Operations |
| Pena | Wilfredo | Operations |
| Puls | Lou | Operations |
| Reay | Michael | Operations |
| Rowan | Haydn | Operations |
| Ryan | Robert | Operations |
| **MURCHISON** | | |
| Merry | Clarence | Operations |
| Merry | Jolene | Operations |

| PERTH | | |
|---|---|---|
| Anderson | Craig | Astrophysics |
| Bastholm | Eric | Operations |
| Bignall | Hayley | Operations |
| Collins | Daniel | Operations |
| Drake | Marilyn | Operations |
| Ferguson | Kevin | Operations |
| Gurkan Uygun | Gulay | Astrophysics |
| Guzman | Juan Carlos | Operations |
| Haskins | Craig | Operations |
| Heald | George | Astrophysics |
| Hotan | Aidan | Project Specialist |
| Huynh | Minh | Astrophysics |
| Reynolds | Cormac | Operations |
| Riseley | Christopher | Astrophysics |
| **CANBERRA** | | |
| Zamora-Pullin | Kobi | Astrophysics |
| **CANBERRA DEEP SPACE COMMUNICATION COMPLEX** | | |
| Horiuchi | Shinji | Astrophysics |
| Nagle | Glen | Communications and Outreach |

# D: Observing programs

## OBSERVATIONS ALLOCATED TIME BY THE TIME ASSIGNMENT COMMITTEE

A small number of 'Target of Opportunity' observations are not listed. Proposal cover sheets are available through the ATNF proposal application system, OPAL (http//opal.atnf.csiro.au).

## OBSERVATIONS MADE WITH THE COMPACT ARRAY, OCTOBER 2015 TO SEPTEMBER 2016

| Observers | Program | No. |
|---|---|---|
| Stevens, Edwards, Wark, Wieringa | ATCA calibrators | C007 |
| Staveley-Smith, Gaensler, Indebetouw, Matsuura, Ng, Tzioumis, Zanardo | Supernova remnant 1987A | C015 |
| Ryder, Kool, Stockdale, Kotak, Polshaw, Yuan, Romero-Canizales, Renaud | NAPA observations of core-collapse supernovae | C1473 |
| Edwards, Stevens, Ojha, Kadler, Lovell, Mueller, Wilms, Blanchard, Macquart | ATCA monitoring of gamma-ray loud AGN | C1730 |
| Voronkov, Goedhart, Maswanganye, Ellingsen, Sobolev, Green, Breen, van der Walt, Parfenov | Understanding periodic flares of the methanol masers | C1929 |
| Filipovic, de Horta, Bozzetto, Crawford, Tothill | G1.9+0.3: youngest Galactic SNR evolution study | C1952 |
| Possenti, Wieringa, Esposito, Burgay, Israel, Rea | Continuum radio emission from magnetars in outburst | C2456 |
| Miller-Jones, Maria, Migliari | The disc wind–jet connection in black-hole transients | C2514 |
| Cavallaro, Trigilio, Norris, Umana, Ingallinera, Buemi, Leto, Franzen, Marvil, Bufano | Stellar radio emission in the SKA era: the SCORPIO project | C2515 |
| Miller-Jones, Jonker, Maccarone, Nelemans, Sivakoff, Tzioumis | Constraining black-hole formation with triggered LBA astrometry | C2538 |
| Miller-Jones, Sivakoff, Altamirano, Krimm, Russell, Curran, Soria | Jet–disc coupling in black-hole X-ray binary outbursts | C2601 |
| Michalowski, Gentile, Hjorth, Krumholz, Tanvir, Kamphuis, Burlon, Baes, Basa, Berta, Castro Ceron, D'Elia, Elliott, Greiner, Hunt, Koprowski, Le Floc'h, Malesani, Murphy, Nicuesa, Palazzi, Rasmussen, Rossi, Savaglio, Schady, Sollerman, de Ugarte Postigo, Watson, van der Werf, Vergani, Xu | ATCA provides the evidence of atomic gas inflow in gamma-ray burst galaxies | C2700 |
| Sadler, Pracy, Croom, Shabala, Allison, Moss, Edwards, McConnell | The birth rate of radio galaxies across cosmic time | C2779 |
| Ellingsen, Imai, Bignall, Breen, Reynolds, Bekki, Beasley, Cioni, Krishnan, Dawson | Measuring the proper motions of the Large and Small Magellanic Clouds | C2798 |
| Aravena, Spilker, Aguirre, de Breuck, Bethermin, Bothwell, Carlstrom, Chapman, Crawford, Fassnacht, Gonzalez, Greve, Gullberg, Hezaveh, Ma, Marrone, Malkan, Murphy, Stark, Strandet, Tothill, Vieira, Weiss | A molecular gas survey of the brightest and most distant star-forming galaxies discovered by the SPT | C2818 |
| Nicuesa Guelbenzu, Klose, Michalowski, Palazzi, Greiner, Hunt, Rossi, Bell | Revealing the dust-obscured star-formation rate in short-GRB host galaxies | C2840 |
| Qiao, Walsh, Green, Dawson, Jones, Cunningham, Jones, Gomez, Imai, Ellingsen, Breen, Lowe, Shen | SPLASH: accurate OH maser positions | C2872 |
| Edge, Hogan, McDonald, Hlavacek-larrondo, Benson, Carlstrom, Holzapfel, Marrone, Sadler, Mahony, Allen, Stadler, Forman, Mcnamara, von der Linden, Brodwin, Stark, Reichardt | AGN feedback in SPT cluster cores | C2884 |
| Sivakoff, Tetarenko, Miller-Jones, Bahramian, Chomiuk, Heinke, Maccarone, Plotkin, Russell, Strader, Tremou | Searching for the first transient black-hole X-ray binary in a Galactic globular cluster | C2902 |

| | | |
|---|---|---|
| Manilla Robles, Dunne, Maddox, Stevens, Oteo, Zhang, Ivison | Zooming in on high-redshift galaxy formation | C2905 |
| Bannister, Walker, Stevens, Johnston, Bignall, Reynolds, Tuntsov, Sadler, Murphy | ATESE: an ATCA survey for extreme scattering events | C2914 |
| Massardi, Galluzzi, Bonaldi, burigana, Bonavera, Lopez-Caniego, de Zotti, Ekers, Gregorini, Paladino, Mignano, Liuzzo, di Serego Alighieri, Casasola, Toffolatti, tucci, Trombetti | Polarimetric multi-frequency observations of a complete sample of radio sources | C2922 |
| Ott, Mills, Meier, Weiss, Henkel, Staveley-Smith, Rathborne, Contreras, Walsh, Burton, Crocker, Longmore, Yusef-Zadeh, Lang, Jones, Morris, Zhang, Ginsburg, Rosolowsky, Corby, Schilke, Goldsmith, Battersby, Bihr, Bally, Beuther, Menten, Anderson, Morabito, Edwards, Kruijssen | Survey of water and ammonia in the Galactic center (SWAG) | C2927 |
| Horesh, Hancock, Nugent, Gal-Yam, Patat, Sullivan, Kulkarni, Goobar, Silverman, Sternberg, Maguire, Cao | CSMIa supernovae – a different class of Ia supernovae? | C2939 |
| Suarez, Gomez, Bendjoya, Miranda, Green | Monitoring the real-time birth of a planetary nebula | C2949 |
| Greiner, Tingay, Wieringa, Moin, Klose, Schady, van Eerten, van der Horst | Testing the gamma-ray burst fireball scenario | C2955 |
| Dickey, Bania, Brown, Dawson, Jordan, McClure-Griffiths, Anderson, Armentrout, Balser, Wenger | Southern H II region discovery survey (SHRDS) | C2963 |
| Bannister, Walker, Johnston, Stevens, Bignall, Reynolds, Tuntsov | Daily monitoring of ATCA extreme scattering events | C2965 |
| Norris, Tothill, Patkovic, O'Brien, Basu, Clerc, Collier, Crawford, Delhaize, Filipovic, Galvin, de Horta, Huynh, Johnston-Hollitt, Marrone, Marvil, McIntyre, Murphy, Reiprich, Salvato, Seymour, Smolcic, Spilker, Stark, Vernstrom, Vieira, Walsh, Wong | ATLAS–SPT: diffuse cluster halo emission in the SPT Deep Field | C2992 |
| Goldman, van Loon, Green, Imai, Groenewegen, Nanni, Wood | Discovering metal-poor circumstellar OH masers | C2996 |
| Dodson, Stevens, Rioja, Jung, Kino, Hada, Lee, Zhao, Lee | Testing the innermost collimation structure of the M87 jet at ~10Rs from the black hole with micro-arcsecond astrometry | C2997 |
| Piro, Ricci, Troja, Gendre, Fiore, Piranomonte, Bannister, Wieringa | ATCA observations of the new class of ultralong GRBs: a local proxy of PopIII explosions? | C3001 |
| Dannerbauer, de Breuck, Emonts, Wylezalek, Santos, Koyama, Seymour, Tanaka, Altieri, Coia, Galametz, Hatch, Lehnert, Miley, Kodama, Rottgering, Sanchez-Portal, Valtchanov, Venemans, Ziegler | Characterizing dusty starbursts at z=2.2 in a high density field | C3003 |
| Papitto, Migliari, Rea, Torres, Bozzo, Ferrigno, Pavan | Coupling accretion and ejection in transitional millisecond pulsars | C3007 |
| Miller-Jones, Diaz trigo, Migliari, Russell, Rahoui | The evolving multi-wavelength spectrum of a transient neutron star X-ray binary | C3010 |
| Moss, Tingay, Sadler, Allison, Maccagni, Stevens, Edwards, Macquart, Morganti, Oosterloo, Glowacki, Musaeva, Shabala, Callingham, Ekers, Beuchert, Wilms, Kadler | Rocking the cradle: a continuing ATCA/XMM-Newton case study of continuum variability in young radio AGN | C3019 |
| Green, Cunningham, Dawson, Walsh, Jones, Lowe, Fissel, Friesen, Novak, Olmi, Lo, Bronfman, Toth, Leurini, Urquhart, Pillai, Kauffmann, Henkel, Hill, Minier, Redman, Wiles | Characterising the properties of two unusual Vela C molecular-cloud filaments, with ATCA ammonia observations | C3024 |
| Huynh, Emonts, Smail, Swinbank, Kimball, Dannerbauer, Seymour, Mao, Thomson, Ivison, Brandt, Casey, Chapman, Hodge, Schinnerer, Walter | Fundamental studies of molecular gas in z~2 ALMA-identified submillimeter galaxies | C3026 |
| Vieira, Aravena, Collier, Fassnacht, Galvin, Grieve, Marrone, McIntyre, Nadolski, O'Brien, Spilker, Tothill, Wong | High-resolution imaging of strongly-lensed radio-bright galaxies from the SPT Survey | C3033 |

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| Sun, Johnston-Hollitt, van Weeren, Forman, Jones | Radio AGN in one of the closest and brightest cool core clusters | C3039 |
| Johnson, Kimball, Marvil, Serra, Kamphuis, Wang, van Vliet Wiegert, Kepley, Green | CHILLING: continuum halos in LVHIS local irregular nearby galaxies | C3041 |
| Bhandari, Bailes, van Straten, Keane, Flynn, Johnston, Caleb, Petroff | Localisation of fast radio bursts | C3044 |
| Shannon, Ravi | The late-time afterglow of a fast radio burst | C3049 |
| Soria, Miller-Jones, Pakull, Motch, Grise', Urquhart | Powerful microquasar jet in the spiral galaxy NGC 300 | C3050 |
| Ng, Bodaghee, Camilo, Gotthelf, Halpern, Leung, Tomsick | Mapping the magnetic field structure of a fast-moving pulsar wind nebula system | C3051 |
| Possenti, Wieringa, Pellizzoni, Pian, Palazzi, Nicastro | Radio follow-up of gravitational radiation sources with ATCA | C3053 |
| Lacy, Mao | Deep, high-resolution imaging of the ES1 SERVS/GEMS Deep Field | C3055 |
| Fenech, Clark, Prinja, Morford, Hindson | Constraining the agents of change – the impact of clumpy winds on massive stellar evolution | C3056 |
| Russell, Altamirano, Curran, Markoff, Miller-Jones, Russell, Tetarenko, Sivakoff, Soria | The evolving jet properties of transient black-hole X-ray binaries | C3057 |
| Troja, Ricci, Cenko, Lien, Giacomazzo, Gehrels | Late-time ATCA observations of GRB afterglows: a test of the magnetar model | C3059 |
| Murphy, Bell, Kaplan, Hobbs, Johnston, Dobie, Zic | Candidate pulsars and steep spectrum sources from the MWA | C3062 |
| Seymour, Afonso, Venemans, Drouart, de Breuck, Norris, Farrah, Jackson, Galvin | Hunting the first black holes with ATCA | C3068 |
| Lang, Purcell, McClure-Griffiths, Mao, Dickey, Thomson, Ludovici | A Faraday study of the non-thermal filaments in the Galactic Centre radio arc | C3069 |
| Fujii, Sano, Fukui, Yoshiike, Fukuda, Mizuno, Filipovic, Grieve, Bozzetto | Revealing the shock-interacting H I kinematics toward the Magellanic superbubble 30 Doradus C | C3070 |
| Jackson, Sadler, Murphy, Franzen, Callingham, Wall, Seymour, Hunstead, Wright | High-frequency observations of a complete sample of bright MWA sources | C3073 |
| Zaw, Greenhill, Horiuchi, Kuiper | First interferometric study of the $H_2O$ maser and AGN host in NGC 5234 | C3074 |
| Mao, Koribalski, Farnes, O'Sullivan, Gallagher, Schnitzeler, Zweibel, Yoast-Hull | The magneto-ionic medium in the Circinus Galaxy | C3075 |
| Tudor, Miller-Jones, Strader, Heinke, Sivakoff, Plotkin, Bahramian | Three new black hole candidates in Galactic globular clusters | C3076 |
| Tudor, Soria, Miller-Jones, Morgan | A new exotic supernova remnant? | C3077 |
| Reid, Ellingsen, Hyland | A search for phase calibrators close to the Galactic plane | C3083 |
| Massardi, Galluzzi, Bonaldi, Lopez-Caniego, de Zotti, Ekers, Lenc, Paladino, Gregorini, di Serego Alighieri, Keating, Jonathan, Leon | A 7-mm polarimetric map of Pictor A | C3085 |
| McClure-Griffiths, Dickey, Liu, Staveley-Smith, Li, Stanimirovic, Wong, Bolatto, Mao, Jameson, Wolfire, Denes | Gas temperature demography in the Magellanic Clouds | C3086 |
| Clements, Cheng, Greenslade, Riechers, Serjeant, Michalowski, Dannerbauer, Omont, Oteo, de Zotti, Andreani, Temi, Gonzalez-Nuevo, Cooray, Valiante, Birkinshaw | Radio investigation of candidate starbursting protoclusters | C3088 |
| Murray, Stanimirovic, McClure-Griffiths | Hunting for molecules in high-velocity clouds | C3090 |

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| Barnes, Longmore, Rathborne, Jackson, Caselli, Ott, Purcell, Stevens, Jordan, Breen, Contreras, Walsh, Whitaker, Henshaw, Walker | Tracing the conversion of gas into stars in a Galaxy-wide sample of high-mass protoclusters: a pilot study | C3091 |
| O'Sullivan, Farnes, Stevens | A new linear polarisation angle calibration standard for 3C286 from 1 to 50 GHz | C3094 |
| Emonts, Allison, Lehnert, Dannerbauer, Ekers, Norris, Villar martin, van Moorsel | The coldest structure in the Early Universe: detection of CO absorption against the cosmic microwave background at z=2? | C3096 |
| Sjouwerman, Pihlstrom, Stroh | Simultaneity and flux bias between 43- and 86-GHz SiO masers | C3097 |
| Stanway, Brown, Levan | Characterising the little-known population of tidal disruption events | C3098 |
| Brown, Stanway, Levan | Late time follow-up of two relativistic tidal disruption flare candidates | C3099 |
| Edge, Hogan, McDonald, Hlavacek-larrondo, Benson, Carlstrom, Holzapfel, Marrone, Sadler, Mahony, Allen, Stadler, Forman, Mcnamara, von der Linden, Brodwin, Stark, Reichardt | AGN feedback in the most distant SPT clusters | C3101 |
| Edwards, Stevens, Corbet, Cheung, Coley, Martin, Coe, McBride, Townsend, Strader, Chomiuk | Flux-density monitoring of a new gamma-ray binary | C3102 |
| Regis, Richter, Colafrancesco | Dark matter searches in Reticulum II | C3103 |
| Denes, McClure-Griffiths, Grenier, Lee | Unveiling the nature of the 'dark' gas in Chamaeleon | C3104 |
| Lee, Gusdorf, Madden, Lebouteiller, Galliano, Ott, Hughes, Shimajiri, Jones | Characterizing low-velocity shocks with the ATCA: high-sensitivity SiO (2–1) observations of N159W | C3105 |
| Alexander, Wieringa, Berger, Saxton | ATCA follow-up of tidal disruption event 2MASX 0740 | C3106 |
| Lynch, Anderson, Fender, Murphy, Bell, Kaplan | Observing radio transient events associated with extreme stellar X-ray flares | C3107 |
| Degenaar, Miller-Jones, Deller, Hessels, Wijnands, Tudor | The accretion-outflow connection for neutron stars | C3108 |
| Hogge, Jackson, Stephens, Whitaker | Extreme linewidths and an $NH_3$ (3,3) maser in G23.33–0.30 | C3111 |
| Glowacki, Sadler, Allison, Moss | A second broad H I-absorption line in a compact radio galaxy? | C3112 |
| Chen, Shen, Ellingsen, Yang, Li, Xu | A sensitive search for 6.7-GHz class II methanol megamaser | C3113 |
| Maddison, Wright, van der Marel, Casassus, van der Plas, Thilliez, van Dishoeck, Pinilla, Walsh, Agnew, Ansdell, Menard, Perez, Marino | Dust traps in transition disks | C3119 |
| Urquhart, Soria, Miller-Jones | Jet bubbles in ultraluminous supersoft sources | C3120 |

## OBSERVATIONS MADE WITH THE PARKES RADIO TELESCOPE, OCTOBER 2015 TO SEPTEMBER 2016

| | | |
|---|---|---|
| Burgay, Kramer, Stairs, Manchester, Lorimer, McLaughlin, Possenti, Ferdman, Camilo, Yuen, Lyne, D'Amico | Timing and geodetic precession in the double pulsar | P455 |
| Hobbs, Bailes, Bhat, Burke, Coles, Keith, Levin, Manchester, Oslowski, Sarkissian, Shannon, Ravi, van Straten, Wang, Kerr, Zhu, Wen, Dai, Reardon | A millisecond pulsar timing array | P456 |
| Kerr, Johnston, Shannon, Weltevrede, Manchester, Hobbs, Possenti | Young pulsar timing: probing the physics of pulsars and neutron stars | P574 |
| Hobbs, Hollow, Shannon, Kerr, Petroff, Ravi, Bannister | PULSE@Parkes (Pulsar Student Exploration online at Parkes) | P595 |

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| Burgay, Rea, Israel, Possenti, Esposito, Sarkissian | Searching for radio pulsations triggered by the X-ray outburst of magnetars | P626 |
| Reynolds, Chippendale, Hellbourg, Sarkissian, Hotan | 64-m/PTF 12-m tests | P628 |
| Hobbs, Van Straten, Manchester, Keith, Bailes, Carretti, Reynolds, Johnston, Jameson, Sarkissian, Shannon | Instrumental calibration for pulsar observing at Parkes | P737 |
| Barr, Bailes, Burgay, Camilo, Champion, Cromartie, Eatough, Hobbs, Jankowski, Johnston, Keane, Keith, Kerr, Kramer, Levin, Lorimer, Manchester, Ng, Ferdman, Possenti, Ransom, Ray, Stairs, Stappers, van Straten, Burke-Spolaor | Timing of binary and millisecond pulsars discovered at Parkes | P789 |
| Camilo, Kerr, Ray, Ransom, Ferrara | Millisecond pulsar searches in unidentified Fermi sources at high Galactic latitudes | P814 |
| Rhee, Staveley-Smith, Wolz, Blake, Wyithe | Mapping the cosmic web | P819 |
| Ng, Champion, Kramer, Bailes, Johnston, Possenti, Stappers, Burgay, van Straten, Bhat, Petroff, Flynn, Barr, Keane, Jameson, Cameron, Caleb, Bhandari, Burke | Initial follow-up of pulsar discoveries from the HTRU Galactic plane survey | P860 |
| Hobbs, Kerr, Shannon, Ravi, Johnston, Hollow, Dai | Analysis of state-switching pulsars | P863 |
| Petroff, Bailes, Barr, Burke-Spolaor, Caleb, Champion, Flynn, Jameson, Johnston, Keane, Kramer, Ng, Possenti, van Straten | A follow-up campaign for fast radio bursts | P871 |
| Possenti, de Martino, Belloni, Burgay, Papitto, Pellizzoni | Investigating the 'transitional' binary pulsar XSS J12270–4859 | P880 |
| Camilo, Scholz, Reynolds, Sarkissian, Johnston | Understanding the remarkable behaviour of radio magnetars | P885 |
| Petroff, Caleb, Keane, Johnston, van Straten | Expanding the rotating radio transient parameter space | P888 |
| Keane, Barr, Bailes, Bates, Bhandari, Bhat, Burgay, Burke-Spolaor, Caleb, Eatough, Flynn, Jameson, Jankowski, Johnston, Keith, Kramer, Levin, Lyon, Morello, Petroff, Ng, Possenti, Stappers, van Straten, Tiburzi | SUPERBx – the survey for pulsars and extragalactic radio bursts extension | P892 |
| Hobbs, Bailes, Bhat, Burke, Coles, Keith, Levin, Manchester, Oslowski, Sarkissian, Shannon, Ravi, van Straten, Wang, Kerr, Zhu, Wen, Dai, Reardon, Dempsey, You, Rosado, Lasky, Toomey | Where are the gravitational waves? | P895 |
| Shannon, Bhat, Kerr, Hobbs, Johnston, Ravi, Tremblay, Ord | Wide-band pulsar emission studies using simultaneous observations with Parkes and the MWA | P896 |
| Kerr, Johnston, Shannon, Hobbs | Planets, plasma or precession? Searching for pulse-profile variation in modulated pulsars | P897 |
| Camilo, Reynolds, Ransom, Kerr, Ray, Halpern | Timing PSR J1417–4402: observing the late phase of millisecond pulsar recyling | P898 |
| Alves, Troland, Arzoumanian, Green, Dawson, Robishaw, Bracco, Soler | An OH Zeeman survey of molecular filaments in the southern sky | P899 |
| Ravi, Shannon | Testing the neutron-star model of fast radio bursts | P901 |
| Mader | An OH and CH molecular survey for dark gas in CMa OB1/R1 | P902 |
| Roberts, Kerr, Camilo, Ransom, Hessels, McLaughlin, Ray, Al Ali, Aliu | Multifrequency orbital studies and extended timing of a Black Widow and a Redback | P903 |
| Deng, Spitler, Hobbs, Johnston, Kramer, Bannister, Keith, Wucknitz, Karuppusamy, Malenta | Timing multiple pulsars simultaneously with a phased-array feed | P909 |
| Staveley-Smith, Bannister, Blake, Deng, Hobbs, Kramer, Phillips, Price, Rhee, Spitler, Wolz, Wucknitz, Wyithe | Fast intensity mapping | P913 |
| Hobbs, Bell, Murphy, Kaplan, Dobie, Hughes | Searching for pulsars from steep-spectrum MWA candidates | P914 |
| Allison, Dawson, Kerr, Johnston, Ntormousi, McClure-Griffiths | Finding the smallest stable structures in the Cold Neutral Medium | P916 |
| Yan, Manchester, Wang, Yuan, Wang, Wen | Mode changing of PSR J0738–4042 | P917 |
| Shannon, Ravi | Do FRBs repeat? A case study of FRB 150807 | P918 |
| Bhat, Deshpande, McSweeney, Ord, Tremblay | Chasing pulsar emission mechanism via sub-pulse drifting | P920 |

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| Ingallinera, Cavallaro, Trigilio, Umana, Carretti, Norris, Buemi, Bufano, Leto, Riggi, Schilliro | Improving the interferometer imaging in the Galactic plane: adding single-dish data | P921 |
| Ilie, Weltevrede, Johnston, Shannon | The polarisation of drifting subpulses of neutron stars | P922 |
| Malenta, Deng, Hobbs, Johnston, Karuppusamy, Keith, Kramer, Spitler, Wieching, Wucknitz | Searching for fast radio bursts with a phased-array feed | P924 |
| Corongiu, Belfiore, Burgay, de Luca, Mignani, Possenti, Salvetti | A search of radio pulsation from the candidate Redback 3FGLJ2039.6–5618 | P926 |
| Lorimer, McLaughlin, Rane, Jiang | Revisiting the Lorimer burst | P928 |
| DeCesar | Timing the highly eccentric binary millisecond pulsar in NGC 6652 | P929 |

## OBSERVATIONS MADE WITH ANTENNAS OF THE CANBERRA DEEP SPACE COMMUNICATION COMPLEX, OCTOBER 2015 TO SEPTEMBER 2016

| | | |
|---|---|---|
| Heise, Engels, Horiuchi, Green | A search for water masers in silicate carbon star candidates | T208 |
| Horiuchi, Hagiwara | Submillimetre and millimetre $H_2O$ masers in the Circinus Galaxy | T209 |
| Castangia, Tarchi, Caccianiga, Severgnini, Della Ceca, Horiuchi | Water masers in Compton-thick AGN | T212 |
| Olmi, Cunningham, Jones, Elia | Segregation of starless/protostellar clumps in the Hi-GAL $l$ = 224 region: physical conditions toward the clumps | T214 |
| Orosz, Gomez, Imai, Horiuchi, Tafoya | Monitoring of $H_2O$ masers in all known water fountains | T215 |

## VLBI (VERY LONG BASELINE INTERFEROMETRY) OBSERVATIONS, OCTOBER 2015 TO SEPTEMBER 2016

| | | |
|---|---|---|
| Ojha, Kadler, Edwards, Carpenter, Team | Physics of gamma-ray emitting AGN | V252 |
| Ellingsen, Reid, Krishnan, Zhang, Green, Honma, Dawson, Zheng, Menten, Fujisawa, Phillips, Goedhart, Xu, Breen, Hyland, Voronkov, Dodson, Shen, Walsh, Brunthaler, Chen, Rioja, Sakai, Sanna, Chibueze | Astrometric observation of methanol masers: determining Galactic structure and investigating high-mass star formation | V255 |
| Miller-Jones, Jonker, Maccarone, Nelemans, Sivakoff, Tzioumis | Constraining black hole formation with LBA astrometry | V447 |
| Horiuchi, Jacobs, Phillips, Stevens, Sotuela, Garcia Miro | 32-GHz celestial reference frame survey for Dec < -45 deg. | V463 |
| Miller-Jones, Moldon, Deller, Shannon, Dubus, Johnston, Paredes, Ribo, Tomsick, Dodson | Mapping the orbit of PSR B1259–63 with LBA astrometry | V486 |
| Petrov, Edwards, Kovalev, Mahony, McConnell, Murphy, Sadler, Schinzel, Taylor | LBA follow-up of probable radio counterparts of Fermi-unassociated sources discovered by ATCA | V493 |
| Reynolds, Kovalev, Kardashev, Bignall, Sokolovsky, Bietenholz, Gurvits, Garrett, Deller, Cimo, Macquart, Jauncey, Edwards, Horiuchi, Tzioumis, Shabala, Lovell, McCallum, Koay | RadioAstron–LBA space VLBI survey of AGN at the highest angular resolution | V511 |
| Reid, Ellingsen, Menten, McCallum, Krishnan, Natusch, Weston, Lovell | A search for 6.7-GHz methanol masers suitable for parallax observations | V534 |
| Macquart, Kirsten, Pen, van Kerkwijk, Main, Jankowski | Resolving the Vela pulsar's emission region directly via scintellometry | V537 |
| Yang, Paragi, Deller, Reynolds, An, Hong, Li, Xia, Yan, Guo | Identifying in-beam calibrators for VLBI astrometry on PSR J0437–4715 | V539 |
| Gurvits, Frey, Lobanov, Beskin, Yang, Paragi, Nokhrina, Sokolovsky, Edwards, Horiuchi | Second-epoch space VLBI visit into core-jet laboratories in the distant Universe | V540 |
| van der Horst, Barniol Duran, Reynolds, Giannios, Paragi | LBA observations of GRB 980425/SN 1998bw: emergence of the radio supernova, 17 years after the gamma-ray burst | V541 |
| Moss, Allison, Sadler, Edwards, Reynolds, Bignall, Phillips, Shabala, Hunstead | Resolving the core conundrum of PKS 1740–517 | V542 |
| Hancock, Anderson, Morgan, Miller-Jones | LBA monitoring of SN2016adj in Cen A | VX024 |

# E: PhD students

PhD students co-supervised by CASS staff (as of December 2016)

| Name | University | Project Title |
|---|---|---|
| Wayne Arcus | Curtin University | Fast radio bursts as cosmic probes |
| Shaila Akhter | University of New South Wales | Turbulence in the interstellar medium and its relationship to massive star formation |
| Ashley Barnes | Liverpool John Moores University | The role of cloud-scale gas properties on the process of stellar mass assembly |
| Shivani Bhandari | Swinburne University of Technology | Transient searches with ASKAP |
| Tui Britton | Macquarie University | Methanol masers in star-forming regions |
| Joseph Callingham | The University of Sydney | The extragalactic sky at low radio frequencies |
| Francesco Cavallaro | University of Catania | Stellar radio emission in the SKA era surveys of the Galactic plane |
| Phoebe de Wilt | Adelaide University | Investigating the connection between star-forming regions and unidentified TeV gamma-ray sources |
| Timothy Galvin | Western Sydney University | Radio emission from star-forming galaxies at high and low redshift |
| Marcin Glowacki | The University of Sydney | Study of H I absorption against distant radio sources through ASKAP |
| Claire-Elise Green | University of New South Wales | Milky Way dynamics and structure |
| Sarah Hegarty | Swinburne University of Technology | Accelerating and enhancing knowledge discovery for the 'petascale astronomy' era |
| Ali Lalbakhsh | Macquarie University | Additive manufacturing for next-generation radio telescopes |
| John Lopez | University of New South Wales | Molecular clouds in the Milky Way: peering into the galactic centre and unravelling the origins of Planck cold clumps |
| Katharina Lutz | Swinburne University of Technology | How do galaxies accrete gas and form stars? |
| Perica Manojlovic | Western Sydney University | Origin of the diffuse emission of galaxy clusters in the SPT field |
| Tiege McCarthy | University of Tasmania | Class I methanol megamasers: a new probe of galactic starbursts |
| Bradley Meyers | Curtin University | Investigating the links between radio pulsar populations that display intermittent emission phenomena at low frequencies |
| Andrew O'Brien | Western Sydney University | ATCA–SPT: a survey of 100 square degrees of the southern sky |
| Daniel Reardon | Monash University | Bayesian analysis of pulsar timing array data to study noise properties of pulsars |
| Elise Sevajean | Universidad de Chile | The physical and kinematical structure of massive and dense cold cores |
| Jesse Swan | University of Tasmania | The evolution of star formation and black-hole activity across cosmic time |
| Ross Turner | University of Tasmania | Dynamical and cosmological evolution of radio AGN and AGN feedback |
| Stuart Weston | AUT University | Data mining for statistical analysis of the faint radio sky: the pathway to EMU |
| Lei Zhang | National Astronomical Observatory, Chinese Academy of Sciences | Millisecond pulsars with FAST |

# F: PhD theses

## THESES AWARDED IN 2016 TO STUDENTS CO-SUPERVISED BY ATNF STAFF

Collier, Jordan (University of Western Sydney, September 2016). “The history and evolution of young and distant radio sources”.

Herzog, Andreas (Macquarie University/Ruhr-Universität Bochum, January 2016). “The broadband spectra of infrared-faint radio sources”.

Kleiner, Dane (Monash University, December 2016). “The multiwavelength properties of galaxies embedded in the cosmic web”.

Krishnan, Vasaant (University of Tasmania, January 2016). “6.7-GHz maser astrometry with the Australian Long Baseline Array”.

Maini, Alessandro (University of Bologna/Macquarie University, October 2016). “Modelling the faint radio sky: the pathway to SKA”.

Rees, Glen (Macquarie University, October 2016). “Cosmology using next-generation radio telescopes”.

Reeves, Sarah (The University of Sydney, February 2016). “H I emission and absorption-line studies of nearby, gas-rich galaxies”.

Wienen, Marion (University of Bonn, June 2016). “Temperatures and distances to high-mass star-forming regions in the inner Galaxy”.

Wong, Graeme (University of Western Sydney, March 2016). “Characterising the structure of molecular clouds”.

# G: Publications

***Indicates publications with CASS staff (not including CASS staff based at CDSCC).**

C – Compact Array, M = Mopra, P = Parkes, V = VLBI, A = ASKAP, S = SKA, T = Tidbinbilla, O = other staff paper

## REFEREED PAPERS WITH DATA FROM, OR RELATED TO, ATNF FACILITIES, AND OTHER STAFF PAPERS


*Abbott, B.P.; Abbott, R.; Abbott, T.D.; Abernathy, M.R.; Acernese, F.; Ackley, K.; Adams, C.; Adams, T.; Addesso, P.; Adhikari, R.X.; and 1564 co-authors. "Localization and broadband follow-up of the gravitational-wave transient GW150914". ApJ, 826, L13 (2016). (A)

*Abbott, B.P.; Abbott, R.; Abbott, T.D.; Abernathy, M.R.; Acernese, F.; Ackley, K.; Adams, C.; Adams, T.; Addesso, P.; Adhikari, R.X.; and 1564 co-authors. "Supplement: Localization and broadband follow-up of the gravitational-wave transient GW150914". ApJS, 225, A8 (2016). (A)

*Acero, F.; Ackermann, M.; Ajello, M.; Baldini, L.; Ballet, J.; Barbiellini, G.; Bastieri, D.; Bellazzini, R.; Bissaldi, E.; Blandford, R.D.; and 151 co-authors "The First Fermi LAT supernova remnant catalog". ApJS, 224, A8 (2016). (O)

Alexander, J.; Gulyaev, S. "Stark broadening of high-order radio recombination lines toward the Orion Nebula". ApJ, 828, A40 (2016). (C)

*Allison, J.R.; Zwaan, M.A.; Duchesne, S.W.; Curran, S.J. "Using 21 cm absorption surveys to measure the average H I spin temperature in distant galaxies". MNRAS, 462, 1341–1350 (2016). (O)

*Anderson, C.S.; Gaensler, B.M.; Feain, I.J. "A study of broadband Faraday rotation and polarization behavior over 1.3–10 GHz in 36 discrete radio sources". ApJ, 825, A59 (2016). (C)

*Aravena, M.; Spilker, J.S.; Bethermin, M.; Bothwell, M.; Chapman, S.C.; de Breuck, C.; Furstenau, R.M.; Gónzalez-López, J.; Greve, T.R.; Litke, K.; and 11 co-authors. "A survey of the cold molecular gas in gravitationally lensed star-forming galaxies at $z > 2$". MNRAS, 457, 4406–4420 (2016). (C)

*Arora, B.S.; Morgan, J.; Ord, S.M.; Tingay, S.J.; Bell, M.; Callingham, J.R.; Dwarakanath, K.S.; For, B.-Q.; Hancock, P.; Hindson, L.; and 11 co-authors. "Ionospheric modelling using GPS to calibrate the MWA. II: Regional ionospheric modelling using GPS and GLONASS to estimate ionospheric gradients". PASA, 33, e031 (2016). (O)

*Avison, A.; Quinn, L.J.; Fuller, G.A.; Caswell, J.L.; Green, J.A.; Breen, S.L.; Ellingsen, S.P.; Gray, M.D.; Pestalozzi, M.; Thompson, M.A.; Voronkov, M.A. "Excited-state hydroxyl maser catalogue from the methanol multibeam survey – I. Positions and variability". MNRAS, 461, 136–155 (2016). (C)

*Banfield, J.K.; Andernach, H.; Kapinska, A.D.; Rudnick, L.; Hardcastle, M.J.; Cotter, G.; Vaughan, S.; Jones, T.W.; Heywood, I.; Wing, J.D.; and eight co-authors. "Radio Galaxy Zoo: discovery of a poor cluster through a giant wide-angle tail radio galaxy". MNRAS, 460, 2376–2384 (2016). (O)

*Bannister, K.W.; Stevens, J.; Tuntsov, A.V.; Walker, M.A.; Johnston, S.; Reynolds, C.; Bignall, H. "Real-time detection of an extreme scattering event: Constraints on Galactic plasma lenses". Sci., 351, 354–356 (2016). (C, V)

Barnes, P.J.; Hernandez, A.K.; O'Dougherty, S.N.; Schap, W.J., III; Muller, E. "The Galactic Census of High- and Medium-mass Protostars. III. $^{12}$CO maps and physical properties of dense clump envelopes and their embedding GMCs". ApJ, 831, A67 (2016). (M)

*Bassa, C. G.; Beswick, R.; Tingay, S. J.; Keane, E. F.; Bhandari, S.; Johnston, S.; Totani, T.; Tominaga, N.; Yasuda, N.; Stappers, B. W.; and three co-authors. "Optical and radio astrometry of the galaxy associated with FRB 150418". MNRAS, 463, L36–L40 (2016). (C)

*Beardsley, A.P.; Hazelton, B.J.; Sullivan, I.S.; Carroll, P.; Barry, N.; Rahimi, M.; Pindor, B.; Trott, C.M.; Line, J.; Jacobs, D.C.; and 56 co-authors. "First season MWA EoR power spectrum results at redshift 7". ApJ, 833, A102 (2016). (O)

*Bell, M.E.; Murphy, T.; Johnston, S.; Kaplan, D.L.; Croft, S.; Hancock, P.; Callingham, J.R.; Zic, A.; Dobie, D.; Swiggum, J.K.; and 28 co-authors. "Time-domain and spectral properties of pulsars at 154 MHz". MNRAS, 461 908–921 (2016). (O)

*Ben Bekhti, N.; Flöer, L.; Keller, R.; Kerp, J.; Lenz, D.; Winkel, B.; Bailin, J.; Calabretta, M.R.; Dedes, L.; and 11 co-authors. "HI4PI: A full-skyH I survey based on EBHIS and GASS". A&A, 594, A116 (2016). (P)

Benaglia, P. "Is the stellar system WR 11 a gamma-ray source?". PASA, 33, e017 (2016). (C)

Bera, A.; Bhattacharyya, S.; Bharadwaj, S.; Bhat, N.D.R.; Chengalur, J.N. "On modelling the Fast Radio Burst population and event rate predictions". MNRAS, 457, 2530–2539 (2016). (P)

Bhat, N.D.R.; Ord, S.M.; Tremblay, S.E.; McSweeney, S.J.; Tingay, S.J. "Scintillation arcs in low-frequency observations of the timing-array millisecond pulsar PSR J0437–4715". ApJ, 818, A86 (2016). (P)

*Bilous, A.V.; Kondratiev, V.I.; Kramer, M.; Keane, E.F.; Hessels, J.W.T.; Stappers, B.W.; Malofeev, V.M.; Sobey, C.; Breton, R.P.; Cooper, S.; and 17 co-authors. "A LOFAR census of non-recycled pulsars: average profiles, dispersion measures, flux densities, and spectra". A&A, 591, A134 (2016). (O)

*Böck, M.; Kadler, M.; Müller, C.; Tosti, G.; Ojha, R.; Wilms, J.; Bastieri, D.; Burnett, T.; Carpenter, B.; Cavazzuti, E.; and 21 co-authors. "Radio and gamma-ray properties of extragalactic jets from the TANAMI sample". A&A, 590, A40 (2016). (V)

Borkar, A.; Eckart, A.; Straubmeier, C.; Kunneriath, D.; Jalali, B.; Sabha, N.; Shahzamanian, B.; García-Marín, M.; Valencia-S, M.; Sjouwerman, L.; and five co-authors. "Monitoring the galactic centre with the Australia Telescope Compact Array". MNRAS, 458, 2336–2349 (2016). (C)

*Boselli, A.; Roehlly, Y.; Fossati, M.; Buat, V.; Boissier, S.; Boquien, M.; Burgarella, D.; Ciesla, L.; Gavazzi, G.; Serra, P. "Quenching of the star formation activity in cluster galaxies". A&A, 596, A11 (2016). (O)

*Bray, J.D. "The sensitivity of past and near-future lunar radio experiments to ultra-high-energy cosmic rays and neutrinos". APh, 77, 1–20 (2016). (P)

*Breen, S.L.; Ellingsen, S.P.; Caswell, J.L.; Green, J.A.; Voronkov, M.A.; Avison, A.; Fuller, G.A.; Quinn, L.J. "12.2-GHz methanol maser MMB follow-up catalogue – IV. Longitude range 20°–60°". MNRAS, 459, 4066–4087 (2016). (P)

*Broderick, J.W.; Fender, R.P.; Breton, R.P.; Stewart, A.J.; Rowlinson, A.; Swinbank, J.D.; Hessels, J.W.T.; Staley, T.D.; van der Horst, A.J.; Bell, M E.; and 23 co-authors. "Low-radio-frequency eclipses of the redback pulsar J2215+5135 observed in the image plane with LOFAR". MNRAS, 459, 2681–2689 (2016). (O)

*Brook, P.R.; Karastergiou, A.; Johnston, S.; Kerr, M.; Shannon, R.M.; Roberts, S. J. "Emission–rotation correlation in pulsars: new discoveries with optimal techniques". MNRAS, 456, 1374–1393 (2016). (P)

*Buitink, S.; Corstanje, A.; Falcke, H.; Hörandel, J.R.; Huege, T.; Nelles, A.; Rachen, J.P.; Rossetto, L.; Schellart, P.; Scholten, O.; and 94 co-authors. "A large light-mass component of cosmic rays at $10^{17}$–$10^{17.5}$ electronvolts from radio observations". Nature, 531, 70–73 (2016). (O)

Burlon, D.; Murphy, T.; Ghirlanda, G.; Hancock, P J.; Parry, R.; Salvaterra, R. "Gamma-ray bursts from massive Population–III stars: clues from the radio band". MNRAS, 459, 3356–3362 (2016). (C)

*Caleb, M.; Flynn, C.; Bailes, M.; Barr, E.D.; Bateman, T.; Bhandari, S.; Campbell-Wilson, D.; Green, A.J.; Hunstead, R.W.; Jameson, A.; and five co-authors. "Fast radio transient searches with UTMOST at 843 MHz". MNRAS, 458, 718–725 (2016). (O)

Caleb, M.; Flynn, C.; Bailes, M.; Barr, E.D.; Hunstead, R.W.; Keane, E.F.; Ravi, V.; van Straten, W. "Are the distributions of fast radio burst properties consistent with a cosmological population?" MNRAS, 458, 708–717 (2016). (P)

*Callingham, J.R.; Gaensler, B.M.; Zanardo, G.; Staveley-Smith, L.; Hancock, P.J.; Hurley-Walker, N.; Bell, M.E.; Dwarakanath, K.S.; Franzen, T.M.O.; Hindson, L.; and 11 co-authors. "Low radio frequency observations and spectral modelling of the remnant of Supernova 1987A". MNRAS, 462, 290–297 (2016). (O)

*Camilo, F.; Ransom, S.M.; Halpern, J.P.; Alford, J.A.J.; Cognard, I.; Reynolds, J.E.; Johnston, S.; Sarkissian, J.; van Straten, W. "Radio disappearance of the magnetar XTE J1810–197 and continued X-ray timing". ApJ, 820, A110 (2016). (P)

*Camilo, F.; Reynolds, J.E.; Ransom, S.M.; Halpern, J.P.; Bogdanov, S.; Kerr, M.; Ray, P.S.; Cordes, J.M.; Sarkissian, J.; Barr, E.D.; Ferrara, E.C. "Discovery of a millisecond pulsar in the 5.4 day binary 3FGL J1417.5–4402: Observing the late phase of pulsar recycling". ApJ, 820, A6 (2016). (P)

*Carbone, D.; van der Horst, A.J.; Wijers, R.A.M.J.; Swinbank, J.D.; Rowlinson, A.; Broderick, J.W.; Cendes, Y.N.; Stewart, A.J.; Bell, M.E.; Breton, R.P.; and 16 co-authors. "New methods to constrain the radio transient rate: results from a survey of four fields with LOFAR". MNRAS, 459, 3161–3174 (2016). (O)

*Carroll, P. A.; Line, J.; Morales, M. F.; Barry, N.; Beardsley, A. P.; Hazelton, B. J.; Jacobs, D. C.; Pober, J. C.; Sullivan, I. S.; Webster, R. L.; and 54 co-authors. "A high reliability survey of discrete Epoch of Reionization foreground sources in the MWA EoR0 field". MNRAS, 461, 4151–4175 (2016). (O)

*Champion, D.J.; Petroff, E.; Kramer, M.; Keith, M.J.; Bailes, M.; Barr, E.D.; Bates, S.D.; Bhat, N.D.R.; Burgay, M.; Burke-Spolaor, S.; and 11 co-authors. "Five new Fast Radio Bursts from the HTRU high latitude survey at Parkes: first evidence for two-component bursts". MNRAS, 460, L30–L34 (2016). (P)

*Chehade, B.; Shanks, T.; Findlay, J.; Metcalfe, N.; Sawangwit, U.; Irwin, M.; González-Solares, E.; Fine, S.; Drinkwater, M.J.; Croom, S.; and three co-authors. "The 2QDES Pilot: the luminosity and redshift dependence of quasar clustering". MNRAS, 459, 1179–1200 (2016). (O)

Chipman, A.; Ellingsen, S.; Sobolev, A.M.; Cragg, D.M. "A sensitive search for predicted methanol maser transitions with the Australia Telescope Compact Array". PASA, 33, e056 (2016). (C)

*Chu, Q.; Howell, E.J.; Rowlinson, A.; Gao, H.; Zhang, B.; Tingay, S.J.; Boër, M.; Wen, L. "Capturing the electromagnetic counterparts of binary neutron star mergers through low-latency gravitational wave triggers". MNRAS, 459, 121–139 (2016). (O)

*Clark, C.J.; Pletsch, H.J.; Wu, J.; Guillemot, L.; Camilo, F.; Johnson, T.J.; Kerr, M.; Allen, B.; Aulbert, C.; Beer, C.; and seven co-authors. "The braking index of a radio-quiet gamma-ray pulsar". ApJ, 832, L15 (2016). (O)

Collet, C.; Nesvadba, N.P.H.; De Breuck, C.; Lehnert, M.D.; Best, P.; Bryant, J.J.; Hunstead, R.; Dicken, D.; Johnston, H. "Kinematic signatures of AGN feedback in moderately powerful radio galaxies at z ~ 2 observed with SINFONI". A&A, 586, A152 (2016). (C)

*Contreras, Y.; Garay, G.; Rathborne, J.M.; Sanhueza, P. "Fragmentation in filamentary molecular clouds". MNRAS, 456, 2041–2051 (2016). (M)

*Corbet, R.H.D.; Chomiuk, L.; Coe, M.J.; Coley, J.B.; Dubus, G.; Edwards, P.G.; Martin, P.; McBride, V.A.; Stevens, J.; Strader, J.; and two co-authors. "A luminous gamma-ray binary in the Large Magellanic Cloud". ApJ, 829, A105 (2016). (C)

*Cordes, J.M.; Shannon, R.M.; Stinebring, D.R. "Frequency-dependent dispersion measures and implications for pulsar timing". ApJ, 817, A16 (2016). (O)

*Cormier, D.; Bigiel, F.; Wang, J.; Pety, J.; Usero, A.; Roychowdhury, S.; Carton, D.; van der Hulst, J.M.; Jozsa, G.I.G.; Gonzales Garcia, M.; Saintonge, A. "The Bluedisk Survey: molecular gas distribution and scaling relations in the context of galaxy evolution". MNRAS, 463, 1724–1739 (2016). (O)

*Cowley, M.J.; Spitler, L.R.; Tran, K.-V.H.; Rees, G.A.; Labbé, I.; Allen, R.J.; Brammer, G.B.; Glazebrook, K.; Hopkins, A.M.; Juneau, S.; and eight co-authors. "ZFOURGE catalogue of AGN candidates: an enhancement of 160-μm-derived star formation rates in active galaxies to z = 3.2". MNRAS, 457, 629–641 (2016). (O)

Crawford, F.; Rane, A.; Tran, L.; Rolph, K.; Lorimer, D.R.; Ridley, J.P. "A search for highly dispersed fast radio bursts in three Parkes multibeam surveys". MNRAS, 460, 3370–3375 (2016). (P)

*Croft, S.; Kaplan, D.L.; Tingay, S.J.; Murphy, T.; Bell, M.E.; Rowlinson, A.; for the MWA Collaboration; Adrián-Martínez, S.; Ageron, M.; Albert, A.; and 128 co-authors. "Murchison Widefield Array limits on radio emission from ANTARES neutrino events". ApJ, 820, L24 (2016). (O)

*Cromartie, H.T.; Camilo, F.; Kerr, M.; Deneva, J.S.; Ransom, S.M.; Ray, P.S.; Ferrara, E.C.; Michelson, P.F.; Wood, K.S. "Six new millisecond pulsars from Arecibo searches of Fermi gamma-ray sources". ApJ, 819, A34 (2016). (O)

*Cruciani, A.; Battistelli, E.S.; Carretti, E.; de Bernardis, P.; Genova-Santos, R.; Masi, S.; Mason, B.; Perera, D.; Piacentini, F.; Reach, B.; Rubino-Martin, J.A. "Detailed study of the microwave emission of the supernova remnant 3C 396". MNRAS, 459, 4224–4232 (2016). (P)

*Curran, S.J.; Allison, J.R.; Whiting, M.T.; Sadler, E.M.; Combes, F.; Pracy, M.B.; Bignell, C.; Athreya, R. "A search for H I and OH absorption in z ≳ 3 CO emitters". MNRAS, 457, 3666–3677 (2016). (O)

*Curran, S.J.; Duchesne, S.W.; Divoli, A.; Allison, J.R. "A comparative study of intervening and associated H I 21-cm absorption profiles in redshifted galaxies". MNRAS, 462, 4197–4207 (2016). (O)

*Curran, S.J.; Reeves, S.N.; Allison, J.R.; Sadler, E.M. "A correlation between the H I 21-cm absorption strength and impact parameter in external galaxies". MNRAS, 459, 4136–4143 (2016). (O)

*Dai, S.; Johnston, S.; Bell, M.E.; Coles, W.A.; Hobbs, G.; Ekers, R.D.; Lenc, E. "Detecting pulsars with interstellar scintillation in variance images". MNRAS, 462, 3115–3122 (2016). (O)

Dénes, H.; Kilborn, V.A.; Koribalski, B.S.; Wong, O.I. " H I-deficient galaxies in intermediate-density environments". MNRAS, 455, 1294–1308 (2016). (C, P)

*Deneva, J.S.; Ray, P.S.; Camilo, F.; Halpern, J.P.; Wood, K.; Cromartie, H.T.; Ferrara, E.; Kerr, M.; Ransom, S.M.; Wolff, M.T.; and two co-authors. "Multiwavelength observations of the Redback Millisecond Pulsar J1048+2339". ApJ, 828, A105 (2016). (O)

*Duev, D.A.; Pogrebenko, S.V.; Cimò, G.; Molera Calvés, G.; Bocanegra Bahamón, T.M.; Gurvits, L.I.; Kettenis, M.M.; Kania, J.; Tudose, V.; Rosenblatt, P.; and 26 co-authors. "Planetary Radio Interferometry and Doppler Experiment (PRIDE) technique: A test case of the Mars Express Phobos fly-by". A&A, 593, A34 (2016). (V)

*Edwards, P.G. & Tingay, S.J. "The parsec-scale morphology of southern GPS sources". PASA, 33, e060 (2016). (V)

*Emonts, B.H.C.; Lehnert, M.D.; Villar-Martín, M.; Norris, R.P.; Ekers, R.D.; van Moorsel, G.A.; Dannerbauer, H.; Pentericci, L.; Miley, G.K.; Allison, J.R.; and 12 co-authors. "Molecular gas in the halo fuels the growth of a massive cluster galaxy at high redshift". Sci., 354, 1128–1130 (2016). (C)

*Ewall-Wice, A.; Dillon, Joshua S.; Hewitt, J.N.; Loeb, A.; Mesinger, A.; Neben, A.R.; Offringa, A.R.; Tegmark, M.; Barry, N.; Beardsley, A.P.; and 55 co-authors. "First limits on the 21 cm power spectrum during the Epoch of X-ray heating". MNRAS, 460, 4320–4347 (2016). (O)

*Federrath, C.; Rathborne, J.M.; Longmore, S.N.; Kruijssen, J.M.D.; Bally, J.; Contreras, Y.; Crocker, R.M.; Garay, G.; Jackson, J.M.; Testi, L.; Walsh, A.J. "The link between turbulence, magnetic fields, filaments, and star formation in the central molecular zone cloud G0.253+0.016". ApJ, 832, A143 (2016). (M)

*Fontani, F.; Commerçon, B.; Giannetti, A.; Beltrán, M.T.; Sánchez-Monge, A.; Testi, L.; Brand, J.; Caselli, P.; Cesaroni, R.; Dodson, R.; and four co-authors. "Magnetically regulated fragmentation of a massive, dense, and turbulent clump". A&A, 593, L14 (2016). (O)

For, B.-Q.; Staveley-Smith, L.; McClure-Griffiths, N.M.; Westmeier, T.; Bekki, K. "The distance and properties of hydrogen clouds in the Leading Arm of the Magellanic System". MNRAS, 461, 892–907 (2016). (C)

*Frank, B.S.; Morganti, R.; Oosterloo, T.; Nyland, K.; Serra, P. "A rare example of low surface-brightness radio lobes in a gas-rich early-type galaxy: the story of NGC 3998". A&A, 592, A94 (2016). (O)

*Franzen, T.M.O.; Jackson, C.A.; Offringa, A.R.; Ekers, R.D.; Wayth, R.B.; Bernardi, G.; Bowman, J.D.; Briggs, F.; Cappallo, R.J.; Deshpande, A.A.; and 23 co-authors. "The 154 MHz radio sky observed by the Murchison Widefield Array: noise, confusion, and first source count analyses". MNRAS, 459, 3314–3325 (2016). (O)

Frick, P.; Stepanov, R.; Beck, R.; Sokoloff, D.; Shukurov, A.; Ehle, M.; Lundgren, A. "Magnetic and gaseous spiral arms in M83". A&A, 585, A21 (2016). (C)

*Fukui, Y.; Torii, K.; Ohama, A.; Hasegawa, K.; Hattori, Y.; Sano, H.; Ohashi, S.; Fujii, K.; Kuwahara, S.; Mizuno, N.; and six co-authors. "The two molecular clouds in RCW 38: Evidence for the formation of the youngest super star cluster in the Milky Way triggered by cloud-cloud collision". ApJ, 820, A26 (2016). (M)

Galluzzi, V. & Massardi, M. "The polarimetric multi-frequency radio sources properties". IJMPD, 25, A1640005 (2016). (C)

*Galvin, T.J.; Seymour, N.; Filipovic, M.D.; Tothill, N.F.H.; Marvil, J.; Drouart, G.; Symeonidis, M.; Huynh, M.T. "Characterising the radio continuum emission from intense starburst galaxies". MNRAS, 461, 825–838 (2016). (C)

*George, M.; Orchiston, W.; Slee, B.; Wielebinski, R. "The early history of low frequency radio astronomy in Australia. 6: Michael Bessell and the University of Tasmania's Richmond field station near Hobart". JAHH, 19, 185–194 (2016). (O)

*Giese, N.; van der Hulst, T.; Serra, P.; Oosterloo, T. "Non-parametric estimation of morphological lopsidedness". MNRAS, 461, 1656–1673 (2016). (O)

*Girard, J.N.; Zarka, P.; Tasse, C.; Hess, S.; de Pater, I.; Santos-Costa, D.; Nenon, Q.; Sicard, A.; Bourdarie, S.; Anderson, J.; and 64 co-authors. "Imaging Jupiter's radiation belts down to 127 MHz with LOFAR". A&A, 587, A3 (2016). (O)

*Giroletti, M.; Massaro, F.; D'Abrusco, R.; Lico, R.; Burlon, D.; Hurley-Walker, N.; Johnston-Hollitt, M.; Morgan, J.; Pavlidou, V.; Bell, M.; and 47 co-authors. "High-energy sources at low radio frequency: the Murchison Widefield Array view of Fermi blazars". A&A, 588, A141 (2016). (O)

*Gómez, J.F.; Uscanga, L.; Green, J.A.; Miranda, L.F.; Suárez, O.; Bendjoya, P. "Polarization properties of OH emission in planetary nebulae". MNRAS, 461, 3259–3273 (2016). (C)

*Green, C.-E.; Cunningham, M.R.; Green, J.A.; Dawson, J.R.; Jones, P.A.; López-Sánchez, Á.R.; Verdes-Montenegro, L.; Henkel, C.; Baan, W.A.; Martín, S. "Dense circumnuclear molecular gas in starburst galaxies". MNRAS, 457, 2470–2479 (2016). (C)

*Greiner, J.; Michałowski, M.J.; Klose, S.; Hunt, L.K.; Gentile, G.; Kamphuis, P.; Herrero-Illana, R.; Wieringa, M.; Krühler, T.; Schady, P.; and eight co-authors. "Probing dust-obscured star formation in the most massive gamma-ray burst host galaxies". A&A, 593, A17 (2016). (C)

*Guzmán, A.E.; Garay, G.; Rodríguez, L.F.; Contreras, Y.; Dougados, C.; Cabrit, S. "A protostellar jet emanating from a hypercompact H II region". ApJ, 826, A208 (2016). (C)

*Hagiwara, Y.; Horiuchi, S.; Doi, A.; Miyoshi, M.; Edwards, P.G. "A search for submillimeter $H_2O$ masers in active galaxies: The detection of 321 GHZ $H_2O$ maser emission in NGC 4945". ApJ, 827, A69 (2016). (T)

Han, J.; Wang, C.; Xu, J.; Han, J.-L. “Spectral indices for radio emission of 228 pulsars”. RAA, 16, A159 (2016). (P)

*Hancock, P.J.; Drury, J.A.; Bell, M.E.; Murphy, T.; Gaensler, B.M. “Radio variability in the Phoenix Deep Survey at 1.4 GHz”. MNRAS, 461, 3314–3321 (2016). (C)

Hardcastle, M.J.; Lenc, E.; Birkinshaw, M.; Croston, J.H.; Goodger, J.L.; Marshall, H.L.; Perlman, E.S.; Siemiginowska, A.; Stawarz, L.; Worrall, D.M. “Deep Chandra observations of Pictor A”. MNRAS, 455, 3526–3545 (2016). (C)

*Harvey-Smith, L.; Allison, J.R.; Green, J.A.; Bannister, K.W.; Chippendale, A.; Edwards, P.G.; Heywood, I.; Hotan, A. W.; Lenc, E.; Marvil, J.; and seven co-authors. “High-velocity OH megamasers in IRAS 20100–4156: evidence for a supermassive black hole”. MNRAS, 460, 2180–2185 (2016). (A, C)

*Heald, G.; de Blok, W.J.G.; Lucero, D.; Carignan, C.; Jarrett, T.; Elson, E.; Oozeer, N.; Randriamampandry, T.H.; van Zee, L. “Neutral hydrogen and magnetic fields in M83 observed with the SKA Pathfinder KAT-7”. MNRAS, 462, 1238–1255 (2016). (O)

Heesen, V.; Dettmar, R.-J.; Krause, M.; Beck, R.; Stein, Y. “Advective and diffusive cosmic ray transport in galactic haloes”. MNRAS, 458, 332–353 (2016). (C)

*Henshaw, J.D.; Longmore, S.N.; Kruijssen, J.M.D.; Davies, B.; Bally, J.; Barnes, A.; Battersby, C.; Burton, M.; Cunningham, M.R.; Dale, J.E.; and 16 co-authors. “Molecular gas kinematics within the central 250 pc of the Milky Way”. MNRAS, 457, 2675–2702 (2016). (M)

*Herrera-Ruiz, N.; Middelberg, E.; Norris, R.P.; Maini, A. “Unveiling the origin of the radio emission in radio-quiet quasars”. A&A, 589, L2 (2016). (O)

*Herzog, A.; Norris, R.P.; Middelberg, E.; Seymour, N.; Spitler, L.R.; Emonts, B.H.C.; Franzen, T.M.O.; Hunstead, R.; Intema, H.T.; Marvil, J.; and 51 co-authors. “The radio spectral energy distribution of infrared-faint radio sources”. A&A, 593, A130 (2016). (A, C).

*Heywood, I.; Bannister, K.W.; Marvil, J.; Allison, J.R.; Ball, L.; Bell, M.E.; Bock, D.C.-J.; Brothers, M.; Bunton, J.D.; Chippendale, A.P.; and 38 co-authors. “Wide-field broad-band radio imaging with phased array feeds: a pilot multi-epoch continuum survey with ASKAP–BETA”. MNRAS, 457, 4160–4178 (2016). (A)

*Heywood, I.; Jarvis, M.J.; Baker, A.J.; Bannister, K.W.; Carvalho, C.S.; Hardcastle, M.; Hilton, M.; Moodley, K.; Smirnov, O.M.; Smith, D.J.B.; and two co-authors. “A deep/wide 1–2 GHz snapshot survey of SDSS Stripe 82 using the Karl G. Jansky Very Large Array in a compact hybrid configuration”. MNRAS, 460, 4433–4452 (2016). (O)

*Hindson, L.; Johnston-Hollitt, M.; Hurley-Walker, N.; Callingham, J.R.; Su, H.; Morgan, J.; Bell, M.; Bernardi, G.; Bowman, J.D.; Briggs, F.; and 33 co-authors. “A Large-Scale, Low-Frequency Murchison Widefield Array Survey of Galactic H II Regions between 260 < *l* < 340”. PASA, 33, e020 (2016). (O)

*Hobbs, G.; Heywood, I.; Bell, M.E.; Kerr, M.; Rowlinson, A.; Johnston, S.; Shannon, R.M.; Voronkov, M.A.; Ward, C.; Banyer, J.; and 68 co-authors. “A pilot ASKAP survey of radio transient events in the region around the intermittent pulsar PSR J1107–5907”. MNRAS, 456, 3948–3960 (2016). (A, P)

Horesh, A.; Hotokezaka, K.; Piran, T.; Nakar, E.; Hancock, P. “Testing the magnetar model via late-time radio observations of two macronova candidates”. ApJ, 819, L22 (2016). (C)

*Ingallinera, A.; Trigilio, C.; Leto, P.; Umana, G.; Buemi, C.; Bufano, F.; Agliozzo, C.; Riggi, S.; Flagey, N.; Silva, K.; and two co-authors. “High-resolution Very Large Array observations of 18 MIPSGAL bubbles”. MNRAS, 463, 723–739 (2016). (O)

*Jackson, N.; Tagore, A.; Deller, A.; Moldón, J.; Varenius, E.; Morabito, L.; Wucknitz, O.; Carozzi, T.; Conway, J.; Drabent, A.; and 69 co-authors. “LBCS: The LOFAR Long-Baseline Calibrator Survey”. A&A, 595, A86 (2016). (O)

*Jauncey, D.; Bignall, H.; Kedziora-Chudczer, L.; Koay, J.; Lovell, J.; Macquart, J.-P.; Ojha, R.; Pursimo, T.; Reynolds, C.; Rickett, B. “Interstellar scintillation and scattering of micro-arc-second AGN”. Galax., 4, A62 (2016). (O)

*Johnson, M.D.; Kovalev, Y.Y.; Gwinn, C.R.; Gurvits, L.I.; Narayan, R.; Macquart, J.-P.; Jauncey, D.L.; Voitsik, P.A.; Anderson, J.M.; Sokolovsky, K.V.; Lisakov, M.M. “Extreme brightness temperatures and refractive substructure in 3C273 with RadioAstron”. ApJ, 820, L10 (2016). (O)

*Kadler, M.; Krauß, F.; Mannheim, K.; Ojha, R.; Müller, C.; Schulz, R.; Anton, G.; Baumgartner, W.; Beuchert, T.; Buson, S.; and 34 co-authors. “Coincidence of a high-fluence blazar outburst with a PeV-energy neutrino event”. Nature Physics, 12, 807–814 (2016). (V)

Kalberla, P.M.W.; Kerp, J.; Haud, U.; Winkel, B.; Ben Bekhti, N.; Flöer, L.; Lenz, D. “Cold Milky Way H I gas in filaments”. ApJ, 821, A117 (2016). (P)

*Katagiri, H.; Sugiyama, S.; Ackermann, M.; Ballet, J.; Casandjian, J.M.; Hanabata, Y.; Hewitt, J.W.; Kerr, M.; Kubo, H.; Lemoine-Goumard, M.; Ray, P.S. “Fermi/LAT study of gamma-ray emission in the direction of the Monoceros Loop supernova remnant”. ApJ, 831, A106 (2016). (O)

Kavanagh, P.J.; Sasaki, M.; Bozzetto, L.M.; Points, S.D.; Crawford, E.J.; Dickel, J.; Filipović, M.D.; Haberl, F.; Maggi, P.; Whelan, E.T. “Two evolved supernova remnants with newly identified Fe-rich cores in the Large Magellanic Cloud”. A&A, 586, A4 (2016). (C)

*Keane, E.F.; Johnston, S.; Bhandari, S.; Barr, E.; Bhat, N.D.R.; Burgay, M.; Caleb, M.; Flynn, C.; Jameson, A.; Kramer, M.; and 31 co-authors. “The host galaxy of a fast radio burst”. Nature, 530, 453–456 (2016). (P, C)

*Kerr, M.; Hobbs, G.; Johnston, S.; Shannon, R.M. “Periodic modulation in pulse arrival times from young pulsars: a renewed case for neutron star precession”. MNRAS, 455, 1845–1854 (2016). (P)

Kim, K.S.; Lilly, S.J.; Miniati, F.; Bernet, M.L.; Beck, R.; O’Sullivan, S.P.; Gaensler, B.M. “Faraday rotation measure synthesis of intermediate redshift quasars as a probe of intervening matter”. ApJ, 829, A133 (2016). (C)

*Koay, J.Y.; Vestergaard, M.; Bignall, H.E.; Reynolds, C.; Peterson, B.M. “Parsec-scale radio morphology and variability of a changing-look AGN: the case of Mrk 590”. MNRAS, 460, 304–316 (2016). (O)

*Kondratiev, V.I.; Verbiest, J.P.W.; Hessels, J.W.T.; Bilous, A.V.; Stappers, B.W.; Kramer, M.; Keane, E.F.; Noutsos, A.; Osłowski, S.; Breton, R.P.; and 22 co-authors. “A LOFAR census of millisecond pulsars”. A&A, 585, A128 (2016). (O)

*Kovalev, Y.Y.; Kardashev, N.S.; Kellermann, K.I.; Lobanov, A.P.; Johnson, M.D.; Gurvits, L. I.; Voitsik, P.A.; Zensus, J.A.; Anderson, J.M.; Bach, U.; and ten co-authors. “RadioAstron observations of the Quasar 3C273: A challenge to the brightness temperature limit”. ApJ, 820, L9 (2016). (O)

*Krauß, F.; Wilms, J.; Kadler, M.; Ojha, R.; Schulz, R.; Trüstedt, J.; Edwards, P.G.; Stevens, J.; Ros, E.; Baumgartner, W.; and 25 co-authors. “The TANAMI

Multiwavelength Program: Dynamic spectral energy distributions of southern blazars". A&A, 591, A130 (2016). (C, V)

Lackington, M.; Fuller, G.A.; Pineda, J.E.; Garay, G.; Peretto, N.; Traficante, A. "Deuteration in infrared dark clouds". MNRAS, 455, 806–819 (2016). (M)

*Lamee, M.; Rudnick, L.; Farnes, J.S.; Carretti, E.; Gaensler, B.M.; Haverkorn, M.; Poppi, S. "Magnetic field disorder and Faraday effects on the polarization of extragalactic radio sources". ApJ, 829, A5 (2016). (O)

*Lasky, P.D.; Mingarelli, C.M.F.; Smith, T.L.; Giblin, J.T., Jr.; Thrane, E.; Reardon, D.J.; Caldwell, R.; Bailes, M.; Bhat, N.D.R.; Burke-Spolaor, S.; and 17 co-authors. "Gravitational-wave cosmology across 29 decades in frequency". Phys.Rev.X, 6, 011035 (2016). (P)

*Lee-Waddell, K.; Spekkens, K.; Chandra, P.; Patra, N.; Cuillandre, J.-C.; Wang, J.; Haynes, M. P.; Cannon, J.; Stierwalt, S.; Sick, J.; Giovanelli, R. "The frequency and properties of young tidal dwarf galaxies in nearby gas-rich groups". MNRAS, 460, 2945–2961 (2016). (O)

Leloudas, G.; Fraser, M.; Stone, N.C.; van Velzen, S.; Jonker, P.G.; Arcavi, I.; Fremling, C.; Maund, J.R.; Smartt, S.J.; Krìhler, T.; and 40 co-authors. "The superluminous transient ASASSN-15lh as a tidal disruption event from a Kerr black hole". NatAs., 1, A0002 (2016). (C).

*Lenc, E.; Gaensler, B.M.; Sun, X.H.; Sadler, E.M.; Willis, A.G.; Barry, N.; Beardsley, A.P.; Bell, M.E.; Bernardi, G.; Bowman, J. D.; and 69 co-authors. "Low-frequency observations of linearly polarized structures in the interstellar medium near the South Galactic Pole". ApJ, 830, A38 (2016). (O)

*Lentati, L.; Shannon, R.M.; Coles, W.A.; Verbiest, J.P.W.; van Haasteren, R.; Ellis, J.A.; Caballero, R.N.; Manchester, R.N.; Arzoumanian, Z.; Babak, S.; and 73 co-authors. "From spin noise to systematics: stochastic processes in the first International Pulsar Timing Array data release". MNRAS, 458, 2161–2187 (2016). (P)

Leverenz, H.; Filipović, M.D.; Bojičić, I.S.; Crawford, E.J.; Collier, J.D.; Grieve, K.; Draskovic, D.; Reid, W.A. "Radio planetary nebulae in the Small Magellanic Cloud". Ap&SS, 361, A108 (2016). (C)

Li, H.-K.; Zhang, J.-S.; Liu, Z.-W.; Lu, D.-R.; Wang, M.; Wang, J. "Oxygen isotopic ratios toward molecular clouds in the Galactic disk". RAA, 16, A011 (2016). (M)

*Li, J.-T.; Beck, R.; Dettmar, R.-J.; Heald, G.; Irwin, J.; Johnson, M.; Kepley, A.A.; Krause, M.; Murphy, E.J.; Orlando, E.; and six co-authors. "CHANG-ES – VI. Probing Supernova energy deposition in spiral galaxies through multiwavelength relationships". MNRAS, 456, 1723–1738 (2016). (O)

*Li, L.; Wang, N.; Yuan, J.P.; Wang, J.B.; Hobbs, G.; Lentati, L.; Manchester, R.N. "Proper motions of 15 pulsars: a comparison between Bayesian and frequentist algorithms". MNRAS, 460, 4011–4017 (2016). (O)

Li, L.; Guo, L.; Wang, G.-L. "Detecting the errors in solar system ephemeris by pulsar timing". RAA, 16, A58 (2016). (P)

*Loi, S.T.; Cairns, I.H.; Murphy, T.; Erickson, P.J.; Bell, M.E.; Rowlinson, A.; Arora, B.S.; Morgan, J.; Ekers, R.D.; Hurley-Walker, N.; Kaplan, D.L. "Density duct formation in the wake of a travelling ionospheric disturbance: Murchison Widefield Array observations". J. Geophys. Res. Space Physics, 121, 1569–1586 (2016). (O)

*Loinard, L.; Kaminski, T.; Serra, P.; Menten, K.M.; Zapata, L.A.; Rodríguez, L.F. "Spatial distribution and kinematics of the molecular material associated with eta Carinae". ApJ, 833, A48 (2016). (C)

Lopez, J.A.P.; Cunningham, M.R.; Jones, P.A.; Marshall, J.P.; Bronfman, L.; Lo, N.; Walsh, A.J. "The chemistry and kinematics of two molecular clouds near Sagittarius A*". MNRAS, 463, 1363–1389 (2016). (M)

*Lynch, C.; Murphy, T.; Ravi, V.; Hobbs, G.; Lo, K.; Ward, C. "Radio detections of southern ultracool dwarfs". MNRAS, 457, 1224–1232 (2016). (C)

Ma, J.; Gonzalez, A.H.; Vieira, J.D.; Aravena, M.; Ashby, M.L.N.; Béthermin, M.; Bothwell, M. S.; Brandt, W.N.; de Breuck, C.; Carlstrom, J.E.; and 13 co-authors. "SPT0346–52: Negligible AGN activity in a compact, hyper-starburst galaxy at z = 5.7". ApJ, 832, A114 (2016). (C)

Ma, Y.K.; Ng, C.-Y.; Bucciantini, N.; Slane, P.O.; Gaensler, B.M.; Temim, T. "Radio polarization observations of the Snail: a crushed pulsar wind nebula in G327.1–1.1 with a highly ordered magnetic field". ApJ, 820, A100 (2016). (C)

MacGregor, M.A.; Wilner, D.J.; Chandler, C.; Ricci, L.; Maddison, S.T.; Cranmer, S.R.; Andrews, S.M.; Hughes, A.M.; Steele, A. "Constraints on planetesimal collision models in debris disks". ApJ, 823, A79 (2016). (C)

*Madison, D.R.; Zhu, X.-J.; Hobbs, G.; Coles, W.; Shannon, R.M.; Wang, J.B.; Tiburzi, C.; Manchester, R.N.; Bailes, M.; Bhat, N.D.R.; and 16 co-authors. "Versatile directional searches for gravitational waves with Pulsar Timing Arrays". MNRAS, 455, 3662–3673 (2016). (P)

*Madrid, J.P.; Donzelli, C.J. "The Abell 85 BCG: A nucleated, coreless galaxy". ApJ, 819, A50 (2016). (O)

*Mahony, E.K.; Morganti, R.; Prandoni, I.; van Bemmel, I. M.; Shimwell, T.W.; Brienza, M.; Best, P.N.; Brüggen, M.; Calistro Rivera, G.; de Gasperin, F.; and 14 co-authors. "The Lockman Hole project: LOFAR observations and spectral index properties of low-frequency radio sources". MNRAS, 463, 2997–3020 (2016). (O)

*Maini, A.; Prandoni, I.; Norris, R.P.; Giovannini, G.; Spitler, L.R. "Compact radio cores in radio-quiet active galactic nuclei". A&A, 589, L3 (2016). (V)

*Maini, A.; Prandoni, I.; Norris, R.P.; Spitler, L.R.; Mignano, A.; Lacy, M.; Morganti, R. "Infrared-faint radio sources in the SERVS deep fields. Pinpointing AGNs at high redshift". A&A, 596, A80 (2016). (O)

Malu, S.; Datta, A.; Sandhu, P. "First detection at 5.5 and 9 GHz of the radio relics in bullet cluster with ATCA". Ap&SS, 361, A255 (2016). (C)

*Manning, E.M.; Holland, B.R.; Ellingsen, S.P.; Breen, S.L.; Chen, X.; Humphries, M. "Comparison of three statistical classification techniques for maser identification". PASA, 33, e015 (2016). (O)

*Marcote, B.; Ribó, M.; Paredes, J.M.; Ishwara-Chandra, C.H.; Swinbank, J.D.; Broderick, J.W.; Markoff, S.; Fender, R.; Wijers, R.A.M.J.; Pooley, G.G.; and 16 co-authors. "Orbital and superorbital variability of LS I +61 303 at low radio frequencies with GMRT and LOFAR". MNRAS, 456, 1791–1802 (2016). (O)

Marsh, T.R.; Gänsicke, B.T.; Hümmerich, S.; Hambsch, F.-J.; Bernhard, K.; Lloyd, C.; Breedt, E.; Stanway, E.R.; Steeghs, D.T.; Parsons, S.G.; and 16 co-authors. "A radio-pulsing white dwarf binary star". Nature, 537, 374–377 (2016). (C)

Martinez Aviles, G.; Ferrari, C.; Johnston-Hollitt, M.; Pratley, L.; Macario, G.; Venturi, T.; Brunetti, G.; Cassano, R.; Dallacasa, D.; Intema, H.T.; and five co-authors. "ATCA observations of the MACS–Planck Radio Halo Cluster Project. I. New detection of a radio halo in PLCK G285.0-23.7". A&A, 595, A116 (2016). (C)

Massardi, M.; Bonaldi, A.; Bonavera, L.; De Zotti, G.; Lopez-Caniego, M.; Galluzzi, V. "The Planck-ATCA Co-eval Observations project: analysis of radio source properties between 5 and 217 GHz". MNRAS, 455, 3249–3262 (2016). (C)

Maxted, N.I.; de Wilt, P.; Rowell, G.P.; Nicholas, B.P.; Burton, M.G.; Walsh, A.; Fukui, Y.; Kawamura, A. "Ammonia excitation imaging of shocked gas towards the W28 gamma-ray source HESS J1801–233". MNRAS, 462, 532–546 (2016). (M)

*McConnell, D.; Allison, J. R.; Bannister, K.; Bell, M. E.; Bignall, H. E.; Chippendale, A. P.; Edwards, P. G.; Harvey-Smith, L.; Hegarty, S.; Heywood, I.; and 64 co-authors. "The Australian Square Kilometre Array Pathfinder: Performance of the Boolardy Engineering Test Array". PASA, 33, e042 (2016). (A)

McGuire, B.A.; Carroll, P.B.; Loomis, R.A.; Finneran, I.A.; Jewell, P.R.; Remijan, A.J.; Blake, G.A. "Discovery of the interstellar chiral molecule propylene oxide ($CH_3CHCH_2O$)". Sci., 352, 1449–1452 (2016). (P)

*McKean, J.P.; Godfrey, L.E.H.; Vegetti, S.; Wise, M.W.; Morganti, R.; Hardcastle, M.J.; Rafferty, D.; Anderson, J.; Avruch, I.M.; Beck, R.; and 68 co-authors. "LOFAR imaging of Cygnus A – direct detection of a turnover in the hotspot radio spectra". MNRAS, 463, 3143–3150 (2016). (O)

Meyer, S.A.; Meyer, M.; Obreschkow, D.; Staveley-Smith, L. "Extended Tully-Fisher relations using H I stacking". MNRAS, 455, 3136–3147 (2016). (P)

*Moin, A.; Edwards, P.G.; Tingay, S.J.; Phillips, C.J.; Tzioumis, A.K.; Amy, S.W.; An, T; Sekido, M.; Wang, Z.-X. "e-VLBI observations of GRB 080409 afterglow with an Australasian radio telescope network". RAA, 16, A164 (2016). (C, V)

*Neben, A.R.; Hewitt, J.N.; Bradley, R.F.; Dillon, J.S.; Bernardi, G.; Bowman, J.D.; Briggs, F.; Cappallo, R.J.; Corey, B.E.; Deshpande, A.A.; and 21 co-authors. "Beam-forming errors in Murchison Widefield Array phased array antennas and their effects on epoch of reionization science". ApJ, 820, A44 (2016). (O)

Nishimura, Y.; Shimonishi, T.; Watanabe, Y.; Sakai, N.; Aikawa, Y.; Kawamura, A.; Yamamoto, S. "Spectral line survey toward molecular clouds in the Large Magellanic Cloud". ApJ, 818, A161 (2016). (M)

*Norris, R.P. "Dawes Review 5: Australian aboriginal astronomy and navigation". PASA, 33, e039 (2016). (O)

*Nyland, K.; Young, L.M.; Wrobel, J.M.; Sarzi, M.; Morganti, R.; Alatalo, K.; Blitz, L.; Bournaud, F.; Bureau, M.; Cappellari, M.; and 15 co-authors. "The ATLAS3D Project – XXXI. Nuclear radio emission in nearby early-type galaxies". MNRAS, 458, 2221–2268 (2016). (O)

*Offringa, A.R.; Trott, C.M.; Hurley-Walker, N.; Johnston-Hollitt, M.; McKinley, B.; Barry, N.; Beardsley, A.P.; Bowman, J.D.; Briggs, F.; Carroll, P.; and 31 co-authors. "Parametrizing epoch of reionization foregrounds: a deep survey of low-frequency point-source spectra with the Murchison Widefield Array". MNRAS, 458, 1057–1070 (2016). (O)

Ohashi, S.; Tatematsu, K.; Fujii, K.; Sanhueza, P.; Nguyen Luong, Q.; Choi, M.; Hirota, Tomoya; Mizuno, N. "Chemical evolution of the $HC_3N$ and $N_2H^+$ molecules in dense cores of the Vela C giant molecular cloud complex". PASJ, 68, A310 (2016). (M)

Olmi, L.; Cunningham, M.; Elia, D.; Jones, P. "The segregation of starless and protostellar clumps in the Hi-GAL $l = 224°$ region". A&A, 594, A58 (2016). (M)

*Palfreyman, J.L.; Dickey, J.M.; Ellingsen, S.P.; Jones, I.R.; Hotan, A.W. "Temporal evolution of the Vela pulsar's pulse profile". ApJ, 820, A64 (2016). (O)

*Pan, Z.; Hobbs, G.; Li, D.; Ridolfi, A.; Wang, P.; Freire, P. "Discovery of two new pulsars in 47 Tucanae (NGC 104)". MNRAS, 459, L26–L30 (2016). (P)

*Pan, Z.; Zheng, X.; Lin., W.; Li., J.; Wang, J.; Fan, L.; Kong, X. "The spatially resolved NUV-r color of local star-forming galaxies and clues for quenching". ApJ, 819, A91 (2016). (O)

*Partridge, B.; López-Caniego, M.; Perley, R.A.; Stevens, J.; Butler, B.J.; Rocha, G.; Walter, B.; Zacchei, A. "Absolute calibration of the radio astronomy flux density scale at 22 to 43 GHz using Planck". ApJ, 821, A61 (2016). (C)

*Paul, S.; Sethi, S.K.; Morales, M.F.; Dwarkanath, K.S.; Udaya Shankar, N.; Subrahmanyan, R.; Barry, N.; Beardsley, A.P.; Bowman, J.D.; Briggs, F.; and 44 co-authors. "Delay spectrum with phase-tracking arrays: Extracting the H I power spectrum from the epoch of reionization". ApJ, 833, A213 (2016). (O)

*Pearson, S.; Besla, G.; Putman, M.E.; Lutz, K.A.; Fernández, X.; Stierwalt, S.; Patton, D.R.; Kim, J.; Kallivayalil, N.; Johnson, K.; Sung, E-C. "Local Volume TiNy Titans: gaseous dwarf-dwarf interactions in the Local Universe". MNRAS, 459, 1827–1846 (2016). (O)

*Petroff, E.; Barr, E.D.; Jameson, A.; Keane, E.F.; Bailes, M.; Kramer, M.; Morello, V.; Tabbara, D.; van Straten, W. "FRBCAT: The Fast Radio Burst Catalogue". PASA, 33, e045 (2016). (P, C)

*Pilia, M.; Hessels, J.W.T.; Stappers, B.W.; Kondratiev, V.I.; Kramer, M.; van Leeuwen, J.; Weltevrede, P.; Lyne, A.G.; Zagkouris, K.; Hassall, T.E.; and 77 co-authors. "Wide-band, low-frequency pulse profiles of 100 radio pulsars with LOFAR". A&A, 586, A92 (2016). (O)

*Piner, B.; Edwards, P.G. "Parsec-scale structure and kinematics of faint TeV HBLs". Galax., 4, 44 (2016). (O)

*Pober, J.C.; Hazelton, B.J.; Beardsley, A.P.; Barry, N.A.; Martinot, Z.E.; Sullivan, I.S.; Morales, M.F.; Bell, M.E.; Bernardi, G.; Bhat, N.D.R.; and 59 co-authors. "The importance of wide-field foreground removal for 21 cm cosmology: A demonstration with early MWA epoch of reionization observations". ApJ, 819, A8 (2016). (O)

*Popov, M V.; Andrianov, A S.; Bartel, N.; Gwinn, C.; Joshi, B.C.; Jauncey, D.; Kardashev, N. S.; Rudnitskii, A.G.; Smirnova, T.V.; Soglasnov, V.A.; and two co-authors. "Distribution of inhomogeneities in the interstellar plasma in the directions of three distant pulsars from observations with the RadioAstron ground-space interferometer". ARep., 60, 792–806 (2016). (V)

*Pracy, M.B.; Ching, J.H.Y.; Sadler, E.M.; Croom, S.M.; Baldry, I.K.; Bland-Hawthorn, J.; Brough, S.; Brown, M.J.I.; Couch, W.J.; Davis, T.M.; and ten co-authors. "GAMA/WiggleZ: the 1.4 GHz radio luminosity functions of high- and low-excitation radio galaxies and their redshift evolution to z = 0.75". MNRAS, 460, 2–17 (2016). (O)

Pratley, L. & Johnston-Hollitt, M. "An improved method for polarimetric image restoration in interferometry". MNRAS, 462, 3483–3501 (2016). (C)

*Price, D.C.; Staveley-Smith, L.; Bailes, M.; Carretti, E.; Jameson, A.; Jones, M.E.; van Straten, W.; Schediwy, S.W. "HIPSR: A digital signal processor for the Parkes 21-cm multibeam receiver". JAI, 5, A1641007 (2016). (P)

*Psychogyios, A.; Charmandaris, V.; Diaz-Santos, T.; Armus, L.; Haan, S.; Howell, J.; Le Floch, E.; Petty, S.M.; Evans, A.S. "Morphological classification of local luminous infrared galaxies". A&A, 591, A1 (2016). (O)

*Punsly, B.; Reynolds, C.; Marziani, P.; O'Dea, C.P. "The extreme ultraviolet spectra of low-redshift radio-loud quasars". MNRAS, 459, 4233–4239 (2016). (O)

*Purser, S.J.D.; Lumsden, S.L.; Hoare, M.G.; Urquhart, J.S.; Cunningham, N.; Purcell, C.R.; Brooks, K.J.; Garay, G.; Gúzman, A.E.; Voronkov, M.A. "A search for ionized jets towards massive young stellar objects". MNRAS, 460, 1039–1053 (2016). (C)

*Qiao, H.-H.; Walsh, A.J.; Gómez, J.F.; Imai, H.; Green, J.A.; Dawson, J.R.; Shen, Z.-Q.; Ellingsen, S.P.; Breen, S.L.; Jones, P.A.; and two co-authors. "Unusual shock-excited OH maser emission in a Young Planetary Nebula". ApJ, 817, A37 (2016). (C)

*Qiao, H.-H.; Walsh, A.J.; Green, J.A.; Breen, S.L.; Dawson, J.R.; Ellingsen, S.P.; Gómez, J.F.; Jordan, C.H.; Shen, Z.-Q.; Lowe, V.; Jones, P.A. "Accurate OH maser positions from the SPLASH pilot region". ApJS, 227, A26 (2016). (C)

Quan, D.; Herbst, E.; Corby, J.F.; Durr, A.; Hassel, G. "Chemical simulations of prebiotic molecules: Interstellar ethanimine isomers". ApJ, 824, A129 (2016). (C)

Rane, A.; Lorimer, D.R.; Bates, S.D.; McMann, N.; McLaughlin, M.A.; Rajwade, K. "A search for rotating radio transients and fast radio bursts in the Parkes high-latitude pulsar survey". MNRAS, 455, 2207–2215 (2016). (P)

*Rathborne, J.M.; Whitaker, J.S.; Jackson, J.M.; Foster, J.B.; Contreras, Y.; Stephens, I.W.; Guzmán, A.E.; Longmore, S.N.; Sanhueza, P.; Schuller, F.; and two co-authors. "Molecular line emission towards high-mass clumps: The MALT90 Catalogue". PASA, 33, e030 (2016). (M)

*Ravi, V.; Shannon, R.M.; Bailes, M.; Bannister, K.; Bhandari, S.; Bhat, N.D.R.; Burke-Spolaor, S.; Caleb, M.; Flynn, C.; Jameson, A.; and six co-authors. "The magnetic field and turbulence of the cosmic web measured using a brilliant fast radio burst". Sci., 354, 1249–1252 (2016). (P, C)

*Rebolledo, D.; Burton, M.; Green, A.; Braiding, C.; Molinari, S.; Wong, G.; Blackwell, R.; Elia, D.; Schisano, E. "The Carina Nebula and Gum 31 molecular complex – I. Molecular gas distribution, column densities, and dust temperatures". MNRAS, 456, 2406–2424 (2016). (M)

*Rees, G.A.; Norris, R.P.; Spitler, L.R.; Herrera-Ruiz, N.; Middelberg, E. "Are the hosts of VLBI-selected radio-AGN different to those of radio-loud AGN?" MNRAS, 458, L49–L53 (2016). (O)

*Rees, G.A.; Spitler, L.R.; Norris, R.P.; Cowley, M.J.; Papovich, C.; Glazebrook, K.; Quadri, R. F.; Straatman, C.M.S.; Allen, R.; Kacprzak, G.G.; and four co-authors. "Radio galaxies in ZFOURGE/NMBS: no difference in the properties of massive galaxies with and without radio-AGN out to z = 2.25". MNRAS, 455, 2731–2744 (2016). (O)

*Reeves, S.N.; Sadler, E.M.; Allison, J.R.; Koribalski, B.S.; Curran, S.J.; Pracy, M.B.; Phillips, C.J.; Bignall, H.E.; Reynolds, C. "H I emission and absorption in nearby, gas-rich galaxies – II. Sample completion and detection of intervening absorption in NGC 5156". MNRAS, 457, 2613–2641 (2016). (C, P, V)

*Ridolfi, A.; Freire, P.C.C.; Torne, P.; Heinke, C.O.; van den Berg, M.; Jordan, C.; Kramer, M.; Bassa, C.G.; Sarkissian, J.; D'Amico, N.; and four co-authors. "Long-term observations of the pulsars in 47 Tucanae – I. A study of four elusive binary systems". MNRAS, 462, 2918–2933 (2016). (P)

*Riggi, S.; Ingallinera, A.; Leto, P.; Cavallaro, F.; Bufano, F.; Schillirò, F.; Trigilio, C.; Umana, G.; Buemi, C.S.; Norris, R.P. "Automated detection of extended sources in radio maps: progress from the SCORPIO survey". MNRAS, 460, 1486–1499 (2016). (C)

*Robinson, R.; Raja, W.; Choudhury, H.; Saikia, D.J. "Sociology of Education and Indian Higher Education Systems". Econ. Polit. Wkly, 51, 67–73 (2016). (O)

*Rowlinson, A.; Bell, M.E.; Murphy, T.; Trott, C.M.; Hurley-Walker, N.; Johnston, S.; Tingay, S.J.; Kaplan, D.L.; Carbone, D.; Hancock, P.J.; and 26 co-authors. "Limits on fast radio bursts and other transient sources at 182 MHz using the Murchison Widefield Array". MNRAS, 458, 3506–3522 (2016). (O)

Ryder, S.D.; Kotak, R.; Smith, I.; Tingay, S.; Kool, E.C.; Polshaw, J. "SN 1978K: An evolved supernova outside our Local Group detected at millimetre wavelengths". A&A, 595, L9 (2016). (C, V)

Said, K.; Kraan-Korteweg, R.C.; Staveley-Smith, L.; Williams, W.L.; Jarrett, T.H.; Springob, C.M. "NIR Tully-Fisher in the zone of avoidance – II. 21 cm H I -line spectra of southern ZOA galaxies". MNRAS, 457, 2366–2376 (2016). (P)

*Salomé, Q.; Salomé, P.; Combes, F.; Hamer, S.; Heywood, I. "Star formation efficiency along the radio jet in Centaurus A". A&A, 586, A45 (2016). (C)

*Schnitzeler, D.H.F.M.; Eatough, R.P.; Ferrière, K.; Kramer, M.; Lee, K.J.; Noutsos, A.; Shannon, R.M. "Radio polarimetry of Galactic Centre pulsars". MNRAS, 459, 3005–3011 (2016). (C)

*Schulz, R.; Kreikenbohm, A.; Kadler, M.; Ojha, R.; Ros, E.; Stevens, J.; Edwards, P.G.; Carpenter, B.; Elsässer, D.; Gehrels, N.; and 13 co-authors. "The gamma-ray emitting radio-loud narrow-line Seyfert 1 galaxy PKS 2004–447. II. The radio view". A&A, 588, A146 (2016). (C, V)

*Serra, P.; Oosterloo, T.; Cappellari, M.; den Heijer, M.; Józsa, G.I.G. "Linear relation between H I circular velocity and stellar velocity dispersion in early-type galaxies, and slope of the density profiles". MNRAS, 460, 1382–1389 (2016). (O)

Shaifullah, G.; Verbiest, J.P.W.; Freire, P.C.C.; Tauris, T.M.; Wex, N.; Osłowski, S.; Stappers, B.W.; Bassa, C.G.; Caballero, R.N.; Champion, D.J.; and 16 co-authors. "21 year timing of the black-widow pulsar J2051–0827". MNRAS, 462, 1029–1038 (2016). (P)

Shakouri, S.; Johnston-Hollitt, M.; Pratt, G.W. "The ATCA REXCESS Diffuse Emission Survey (ARDES) – I. Detection of a giant radio halo and a likely radio relic". MNRAS, 459, 2525–2538 (2016). (C)

*Shannon, R.M.; Lentati, L.T.; Kerr, M.; Bailes, M.; Bhat, N.D.R.; Coles, W.A.; Dai, S.; Dempsey, J.; Hobbs, G.; Keith, M.J.; and 14 co-authors. "The disturbance of a millisecond pulsar magnetosphere". ApJ, 828, L1 (2016). (P)

*Shannon, R.M.; Lentati, L.T.; Kerr, M.; Johnston, S.; Hobbs, G.; Manchester, R.N. "Characterizing the rotational irregularities of the Vela pulsar from 21 yr of phase-coherent timing". MNRAS, 459, 3104–3111 (2016). (P)

*Shara, M.M.; Doyle, T.F.; Lauer, T.R.; Zurek, D.; Neill, J.D.; Madrid, J.-P.; Mikolajewska, J.; Welch, D.L.; Baltz, E.A. "A Hubble Space Telescope Survey for Novae in M87. I. Light and color curves, spatial distributions, and the nova rate". ApJS, 227, A1 (2016). (O)

Smolčić, V.; Delhaize, J.; Huynh, M.; Bondi, M.; Ciliegi, P.; Novak, M.; Baran, N.; Birkinshaw, M.; Bremer, M.N.; Chiappetti, L.; and nine co-authors. "The XXL Survey. XI. ATCA 2.1 GHz continuum observations". A&A, 592, A10 (2016). (C)

*Springob, C.M.; Hong, T.; Staveley-Smith, L.; Masters, K.L.; Macri, L.M.; Koribalski, B.S.; Jones, D.H.; Jarrett, T.H.; Magoulas, C.; Erdoğdu, P. "2MTF – V. Cosmography, beta, and the residual bulk flow". MNRAS, 456, 1886–1900 (2016). (O)

*Staveley-Smith, L.; Kraan-Korteweg, R.C.; Schröder, A.C.; Henning, P.A.; Koribalski, B.S.; Stewart, I.M.; Heald, G. "The Parkes H I Zone of Avoidance Survey". AJ, 151, A52 (2016). (P)

*Stephens, I.W.; Jackson, J.M.; Whitaker, J.S.; Contreras, Y.; Guzmán, A.E.; Sanhueza, P.; Foster, J.B.; Rathborne, J.M. "Linking dense gas from the Milky Way to external galaxies". ApJ, 824, A29 (2016). (O)

*Stewart, A.J.; Fender, R.P.; Broderick, J.W.; Hassall, T.E.; Muñoz-Darias, T.; Rowlinson, A.; Swinbank, J.D.; Staley, T.D.; Molenaar, G.J.; Scheers, B.; and 92 co-authors. "LOFAR MSSS: detection of a low-frequency radio transient in 400 h of monitoring of the North Celestial Pole". MNRAS, 456, 2321–2342 (2016). (O)

*Tabatabaei, F.S.; Martinsson, T.P.K.; Knapen, J.H.; Beckman, J.E.; Koribalski, B.; Elmegreen, B.G. "An empirical relation between the large-scale magnetic field and the dynamical mass in galaxies". ApJ, 818, L10 (2016). (O)

Tendulkar, S.P.; Kaspi, V.M.; Patel, C. "Radio nondetection of the SGR 1806–20 giant flare and implications for fast radio bursts". ApJ, 827, A59 (2016). (P)

Tetarenko, A.J.; Bahramian, A.; Sivakoff, G.R.; Tremou, E.; Linares, M.; Tudor, V.; Miller-Jones, J.C.A.; Heinke, C.O.; Chomiuk, L.; Strader, J.; and six co-authors. "Disc-jet coupling in the Terzan 5 neutron star X-ray binary EXO 1745–248". MNRAS, 460, 345–355 (2016). (C)

*Tiburzi, C.; Hobbs, G.; Kerr, M.; Coles, W.A.; Dai, S.; Manchester, R.N.; Possenti, A.; Shannon, R.M.; You, X.P. "A study of spatial correlations in pulsar timing array data". MNRAS, 455, 4339–4350 (2016). (P)

*Titmarsh, A.M.; Ellingsen, S.P.; Breen, S.L.; Caswell, J.L.; Voronkov, M.A. "A search for water masers associated with class II methanol masers – II. Longitude range 341° to 6°". MNRAS, 459, 157–170 (2016). (C)

*Trott, C.M.; Pindor, B.; Procopio, P.; Wayth, R.B.; Mitchell, D.A.; McKinley, B.; Tingay, S.J.; Barry, N.; Beardsley, A.P.; Bernardi, G.; and 42 co-authors. "CHIPS: The cosmological H I power spectrum estimator". AJ, 818, A139 (2016). (O)

*Tuntsov, A.V.; Walker, M.A.; Koopmans, L.V.E.; Bannister, K.W.; Stevens, J.; Johnston, S.; Reynolds, C.; Bignall, H.E. "Dynamic spectral mapping of interstellar plasma lenses". ApJ, 817, A176 (2016). (C)

*Vedantham, H.K.; Ravi, V.; Hallinan, G.; Shannon, R.M. "The fluence and distance distributions of fast radio bursts". ApJ, 830, A75 (2016). (P)

*Verbiest, J.P.W.; Lentati, L.; Hobbs, G.; van Haasteren, R.; Demorest, P.B.; Janssen, G.H.; Wang, J.-B.; Desvignes, G.; Caballero, R.N.; Keith, M.J.; and 82 co-authors. "The International Pulsar Timing Array: First data release". MNRAS, 458, 1267–1288 (2016). (P)

Voisin, F.; Rowell, G.; Burton, M.G.; Walsh, A.; Fukui, Y.; Aharonian, F. "ISM gas studies towards the TeV PWN HESS J1825–137 and northern region". MNRAS, 458, 2813–2835 (2016). (M)

*Walker, D.L.; Longmore, S.N.; Bastian, N.; Kruijssen, J.M.D.; Rathborne, J.M.; Galván-Madrid, R.; Liu, H.B. "Comparing young massive clusters and their progenitor clouds in the Milky Way". MNRAS, 457, 4536–4545 (2016). (O)

*Walsh, A.J.; Beuther, H.; Bihr, S.; Johnston, K.G.; Dawson, J.R.; Ott, J.; Longmore, S.N.; L.Q. Nguyên; Klessen, R.S.; Ragan, S.; and seven co-authors. "A survey for hydroxyl in the THOR pilot region around W43". MNRAS, 455, 3494–3510 (2016). (O)

*Wang, J.; Koribalski, B.S.; Serra, P.; van der Hulst, T.; Roychowdhury, S.; Kamphuis, P.; Chengalur, J.N. "New lessons from the H I size-mass relation of galaxies". MNRAS, 460, 2143–2151 (2016). (O)

*Wen, Z.G.; Wang, N.; Yuan, J.P.; Yan, W.M.; Manchester, R.N.; Yuen, R.; Gajjar, V. "Investigation of nulling and subpulse drifting properties of PSR J1727–2739". A&A, 592, A127 (2016). (P)

Wiles, B.; Lo, N.; Redman, M.P.; Cunningham, M.R.; Jones, P.A.; Burton, M.G.; Bronfman, L. "Scaled up low-mass star formation in massive star-forming cores in the G333 giant molecular cloud". MNRAS, 458, 3429–3442 (2016). (M)

*Wolfinger, K.; Kilborn, V.A.; Ryan-Weber, E.V.; Koribalski, B.S. "The Ursa Major Cluster Redefined as a 'Supergroup'". PASA, 33, e038 (2016). (O)

Wolz, L.; Tonini, C.; Blake, C.; Wyithe, J.S.B. "Intensity mapping cross-correlations: connecting the largest scales to galaxy evolution". MNRAS, 458, 3399–3410 (2016). (P)

*Wong, G.F.; Horiuchi, S.; Green, J.A.; Tothill, N.F.H.; Sugimoto, K.; Filipovic, M.D. "Implementation of Tidbinbilla 70-m on-the-fly mapping and hydrogen radio recombination line early results". MNRAS, 458, 151–157 (2016). (T)

Yu, N. & Xu, J. "Chemical evolution of Red MSX sources in the Southern Sky". ApJ, 833, A248 (2016). (C, M)

*Zauderer, B.A.; Bolatto, A.D.; Vogel, S.N.; Carpenter, J.M.; Peréz, L.M.; Lamb, J.W.; Woody, D.P.; Bock, D.C.-J.; Carlstrom, J.E.; Culverhouse, T.L.; and 12 co-authors. "The CARMA Paired Antenna Calibration System: Atmospheric phase correction for millimeter wave interferometry and its application to mapping the ultraluminous Galaxy Arp 193". AJ, 151, A18 (2016). (O)

*Zhang, L.; Hobbs, G.; Li, D.; Lorimer, D. Zhang, J.; Yu, M. Yue, Y.-L. Wang, P.; Pan, Z.-C. Dai, S. "Wide-bandwidth drift-scan pulsar surveys of globular clusters: application to early science observations with FAST". RAA, 16, A151 (2016). (O)

*Zhu, X.; Wen, L.; Xiong, J.; Xu, Y.; Wang, Y.; Mohanty, S.D.; Hobbs, G.; Manchester, R.N. "Detection and localization of continuous gravitational waves with pulsar timing arrays: the role of pulsar terms". MNRAS, 461, 1317–1327 (2016). (O)

## PAPERS PUBLISHED IN CONFERENCE PROCEEDINGS USING DATA FROM, OR RELATED TO, ATNF FACILITIES, AND OTHER STAFF PAPERS

*Indicates publications with CASS authors

C = Compact Array, M = Mopra, P = Parkes, V = VLBI, A = ASKAP, S= SKA, T = CDSCC (Tidbinbilla), O = other staff paper

*Akhter, S.; Cunningham, M.R.; Harvey-Smith, L.; Nawaz, M.A.; Jones, P.A.; Purcell, C.; Walsh, A. "High mass star formation: properties of $NH_3$ clumps in southern Galactic plane". In: IAU 315: *From interstellar clouds to star-forming galaxies: universal processes?* Honolulu, USA, 3–7 August 2015, 11, E2 (2016). (M)

*Allison, J.R.; Sadler, E.M.; Moss, V.A.; Harvey-Smith, L.; Heywood, I.; Indermuehle, B.T.; McConnell, D.; Sault, R.J.; Whiting, M.T. "Tracing the neutral gas environments of young radio AGN with ASKAP". In: Astron. Nachr.: *5th Workshop on Compact Steep Spectrum and GHz-Peaked Spectrum Radio Sources*, Rimini, Italy, 27–29 May 2015, 337, 175–179 (eds. K.G. Strassmeier, A. Brandenburg *et al.*) (2016). (A)

*Baldwin, K.G.H.; He, Y.; Orr, B.J.; Warrington, R.B.; Luiten, A.N.; Mirtschin, P.; Tzioumis, T.; Phillips, C.; Aben, G.; Newlands, T. and one co-author. "Dissemination of precise radio-frequency references for environmental sensing over long-haul optical-fiber networks". In: *Optics and Photonics for Energy and the Environment 2016*, Leipzig, Germany, 14–17 November 2016, ETu3A.3 (2016). (V, C, M)

Barnes, P.; Muller, E.; Luong, Q.N.; Nguyen, H. "ThrUMMS: A New View of the Molecular Milky Way". In: IAU 315: *From interstellar clouds to star-forming galaxies: universal processes?* Honolulu, USA, 3–7 August 2015, 11, E5 (2016). (M)

Bartel, N. & Bietenholz, M.F. "Supernova research with VLBI". In: *Supernova Remnants: An Odyssey in Space after Stellar Death*, Chania, Greece, 6–11 June 2016, A133 (2016). (C, P, M)

Benjamin, R.; Barnes, P.; Hernandez, A.; Haffner, L.M.; Hill, A.; Krishnarao, D. "The Vertical Structure of the Spiral Arms of the Milky Way Galaxy". In: VIALACTEA 2016: *The Milky Way as a Star Formation Engine: towards a predictive Galaxy-scale model of the Star Formation Life-Cycle*, Rome, Italy, 26–30 September 2016, 82 (eds. S. Molinari *et al.*) (2016). (M)

Bunton, J.D. "Progress in SKA Central Signal Processing 2016". In: *URSI Asia–Pacific Radio Science Conference*, Seoul, Korea, 21–25 August 2016, 3 p. (2016). (S)

Burton, M.; Ashley, M.; Braiding, C.; Freeman, M.; Kulesa, C.; Wolfire, M.; Hollenbach, D.; Rowell, G.; Lau, J. "Extended carbon emission in the galaxy: Dark gas along the G328 Sightline". In: *From interstellar clouds to star-forming galaxies: universal processes?* Honolulu, USA, 3–7 August 2015, 11, E10 (2016). (M)

*Chippendale, A.P.; Beresford, R.J.; Deng, X.; Leach, M.; Reynolds, J.E.; Kramer, M.; Tzioumis, T. "Testing a modified ASKAP Mark II phased array feed on the 64 m Parkes radio telescope". In: *International Conference on Electromagnetics in Advanced Applications (ICEAA 2016)*, Cairns, Australia, 19–23 September 2016, 909–912 (2016). (P)

*Chippendale, A.P.; McConnell, D.; Bannister, K.; Nikolic, N.; Hotan, A.W.; Smart, K.W.; Shaw, R.D.; Hayman, D.B.; Hay, S.G. "Recent developments in measuring signal and noise in Phased Array Feeds at CSIRO". In: *10th European Conference on Antennas and Propagation (EuCAP)*, Davos, Switzerland, 10–15 April 2016, 1–5 (2016). (A)

*Collier, J.D.; Norris, R.P.; Filipovic, M.D.; Tothill, N.F.H. "An evolutionary sequence of young radio galaxies". In: Astron. Nachr.: *5th Workshop on Compact Steep Spectrum and GHz-Peaked Spectrum Radio Sources*, Rimini, Italy, 27–29 May 2015, 337, 36–41 (eds. K.G. Strassmeier, A. Brandenburg *et al.*) (2016). (C)

*Davis, G.R.; Bock, D.C.; Chrysostomou, A.; Taljaard, C. "Operations concept for the Square Kilometre Array". In: Proc. of SPIE: *Observatory Operations: Strategies, Processes, and Systems VI*, Edinburgh, United Kingdom, 26 June–1 July 2016, 9910, A99100H (eds. A.B. Beck, R.L. Seaman, C.R. Benn) (2016). (S)

*Deshev, B.; Park, C.; Hwang, H.S.; Ziegler, B.; Verdugo, M.; Kamphuis, P.; Finoguenov, A.; Tenjes, P.; Tamm, A. "Building up a cluster: The case of A520". In: ASP Conf. Ser., *Multi-Object Spectroscopy in the Next Decade: Big Questions, Large Surveys, and Wide Fields*, Canary Islands, Spain, 2–6 March 2015, 507, 237–240 (eds. I. Skillen *et al.*) (2016). (O)

*Dolch, T.; NANOGrav Collaboration; Ellis, J.A.; Chatterjee, S.; Cordes, J.M.; Lam, M. T.; Bassa, C.; Bhattacharyya, B.; Champion, D.J.; Cognard, I.; and 28 co-authors. "Single-source gravitational wave limits from the J1713+0747 24-hr global campaign". In: JPhCS: *11th Edoardo Amaldi Conference on Gravitational Waves*, Gwangju, South Korea, 21–26 June 2015, 716, A012014 (2016). (P)

*Dunning, A.; Bowen, M.A.; Hayman, D.B.; Kanapathippillai, J.; Kanoniuk, H.; Shaw, R.B.; Severs, S. "The development of a wideband 'rocket' phased array feed". In: *2016 13th European Radar Conference*, London, UK, 5–7 October 2016, 421–424 (2016). (A)

*Ekers, R.D. "Radio evidence for binary super massive black holes". In: IAU 312: *Star Clusters and Black Holes in Galaxies across Cosmic Time*, Beijing, China, 25–29 August 2014, 10, 26–30 (2016). (O)

Galluzzi, V.; Massardi, M.; Gregorini, L. "Multi-frequency polarisation measurements of PACO radio sources". In: *Active Galactic Nuclei 12: A Multi-Messenger Perspective*, Napoli, Italy, 26–29 September 2016, A57 (2016). (C)

*Guzman, J.C.; Chapman, J.; Marquarding, M.; Whiting, M. "Status report of the end-to-end ASKAP software system: towards early science operations". In: Proc. of SPIE: *Software and Cyberinfrastructure for Astronomy IV*, Edinburgh, UK, 26 June – 1 July 2016, 9913, A991311 (eds. G. Chiozzi, J.C. Guzman) (2016). (A)

*Hampson, G.A.; Bunton, J.D.; Gunst, A.W.; Baillie, P.; bij de Vaate, J.-G. "Introduction to the SKA low correlator and beamformer system". In: Proc. of SPIE: *Ground-based and Airborne Telescopes VI*, Edinburgh, UK, 26 June – 1 July 2016, (eds. H.J. Hall, R. Gilmozzi, H.K. Marshall) 9906, A99062S (2016). (S)

Harada, R.; Onishi, T.; Hughes, A.; Meixner, M.; Sewilo, M.; Indebetouw, R.; Nayak, O.; Tokuda, K.; Morioka, Y.; Fukui, Y.; and three co-authors. "Investigating formation of isolated intermediate/massive YSOs in the LMC". In: IAU 315: *From interstellar clouds to star-forming galaxies: universal processes?* Honolulu, USA, 3–7 August 2015, 11, E32 (2016). (M)

# H: Abbreviations

| | |
|---|---|
| AGN | Active Galactic Nuclei |
| ALMA | Atacama Large Millimeter/submillimeter Array |
| ASKAP | Australian Square Kilometre Array Pathfinder |
| ATCA | Australia Telescope Compact Array |
| ATLAS | Australia Telescope Large Area Survey |
| ATNF | Australia Telescope National Facility |
| BETA | Boolardy Engineering Test Array |
| CASS | CSIRO Astronomy and Space Science |
| CDSCC | Canberra Deep Space Communication Complex |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| EMU | Evolutionary Map of the Universe |
| GRB | Gamma-Ray Burst |
| H I | Neutral Hydrogen |
| HIPASS | H I Parkes All Sky Survey |
| IAU | International Astronomical Union |
| ICRAR | International Centre for Radio Astronomy Research |
| IEEE | Institute of Electrical and Electronics Engineers |
| ISM | Interstellar Medium |
| LBA | Long Baseline Array, used for Australian VLBI observations |
| LMC | Large Magellanic Cloud |
| LOFAR | Low Frequency Array |
| MALT | Millimetre Astronomers Large-area multi-Transition |
| MNRAS | Monthly Notices of the Royal Astronomical Society |
| MRO | Murchison Radio-astronomy Observatory |
| MWA | Murchison Widefield Array |
| MYSO | Massive Young Stellar Object |
| NAPA | Non A-Priori Assignable |
| NASA | National Aeronautics and Space Administration |
| PTF | Parkes Testbed Facility |
| RFI | Radio Frequency Interference |
| SCORPIO | Spectral Camera with Optical Reducer for Photometrical and Interferometrical Observations |
| SKA | Square Kilometre Array |
| SNe | Supernovae |
| SNR | Supernova Remnant |
| SPT | South Pole Telescope |
| VLBI | Very Long Baseline Interferometry |

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