International
Centre for
Radio
Astronomy
Research

Volume 2
2011–2012

2

ICRAR YEARBOOK

2011–2012

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International Centre for
Radio Astronomy Research
www.icrar.org
info@icrar.org

ICRAR is a joint venture between Curtin University and The University of Western Australia with strong support from the West Australian and Australian governments.

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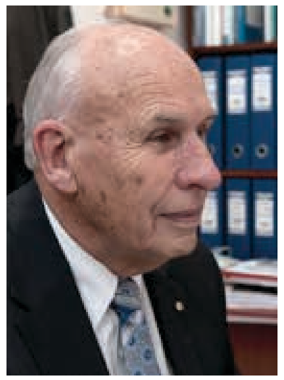
FOREWORD



1
Dr Bernard Bowen,
Chair of the ICRAR Board.
2
Antennas of the Murchison Widefield Array (MWA), the SKA-low frequency precursor.

The International Centre for Radio Astronomy Research, or ICRAR as it is widely known, is an exciting partnership between the Western Australian Government, Curtin University and The University of Western Australia. This Year Book provides the reader with a glimpse of what can be achieved in a field of science, engineering and communication technology when people of competence, goodwill and enthusiasm come together.

ICRAR has research nodes at both Curtin University and The University of Western Australia. ICRAR was founded in 2009 on the substantial contributions of these two universities, together with the Western Australian Government. Their contributions, as well as additional grants won by ICRAR researchers, have resulted in the Government's grant of $20 million leveraging more than $110 million for ICRAR's work over the next few years.

ICRAR has developed signature research themes in Science, Engineering, and Information and Communications Technology. These key areas have attracted professionals to ICRAR from all parts of the world, both as staff members and visitors for short-term stays. ICRAR's programs are clearly exciting not only for researchers but also for students at school and university.

A highlight in the development of ICRAR has been the reaching-out of our researchers to the community, school students and those at university who pursue studies in astronomy and astrophysics or important disciplines like engineering or high performance computing which make the science of radio astronomy possible. Our researchers and outreach professionals have established world-class programs that succeed in raising awareness, understanding and appreciation for astronomical research and the science that ultimately permeates and enriches our everyday lives.

I take this opportunity, through the publication of this Year Book, to thank the Director, the ICRAR executive team, and all those who contribute so much to the development of ICRAR for their professionalism, their attention to detail and their untiring desire to bring the excitement of astrophysics to the people of Western Australia and beyond.

Bernard Bowen AM FTSE
Chair of the ICRAR Board

1
ICRAR staff and students celebrate the SKA site decision.

SKA SITE DECISION AND ANNOUNCEMENT

On May 25, 2012, the site for the Square Kilometre Array (SKA) radio telescope was awarded to both Australia/New Zealand and South Africa.

The decision split the facility, giving Australia the lower frequency part of the telescope that will conduct large surveys of the skies and South Africa the higher frequency part designed for deep and detailed investigations.

Giving the SKA a home was transformational for the project, removing considerable uncertainty and providing a well defined path forward.

'The Centre will actively participate in the design phase of the SKA over the next four years.'

But it was also transformational for ICRAR, with the decision meaning the Centre has completed one of its major milestones.

Founded with a mission to assist Australia in every way with the site bid, ICRAR is proud to have worked with the State and Federal Governments to have a significant part of the SKA hosted in Australia.

The Centre participated directly in the Australian site campaign and promoted awareness of our radio astronomy capability throughout Australia and abroad.

But the site bid is only a small part of the story.

Now ICRAR is focusing its energies on growing into a very strong contributor to the international SKA project.

The Centre will actively participate in the design phase of the SKA over the next four years, contributing to the concepts, ideas, algorithms and technology that will make the project successful.

ICRAR as an organisation has shown it can produce extremely good science and technology.

Early prioritising of low frequency technology and high performance computing, together with experience working on the Australian site, put the Centre in an ideal position to contribute to the low frequency and survey parts of the SKA.

One of the consequences of the site decision for ICRAR is an affirmation of the strategy adopted in putting the ICRAR Plan together—under the leadership of Professors Peter Hall and Peter Quinn, the Centre invested early in low frequency aperture arrays and ICT, two major areas of Australian SKA-low activity in the years to come.

2
Ministers and Vice-Chancellors join Professor Peter Quinn at Governement House to celebrate the SKA site decision. L to R: Senator the Hon Chris Evans, Professor Peter Quinn (Director of ICRAR), the Hon John Day, Professor David Wood (Acting Vice-Chancellor of Curtin University) and Professor Paul Johnson (Vice-Chancellor of UWA).

'ICRAR will continue to collaborate with institutions across the globe, cultivating studentship, learning, outreach, education and research excellence internationally.'

ICRAR has been instrumental in delivering the Murchison Widefield Array (MWA) project, the only low frequency precursor to the SKA, with ICRAR Deputy Director Professor Steven Tingay also the director of the MWA project.

ICRAR is proud to have worked at the Murchison site, supporting site activities, project management, reciever and correlator construction, commissioning of the telescope and the development of the whole data archive system.

The Centre's engagement with West Australian industry on the MWA demonstrates how local industry can be at the forefront of major international science projects.

ICRAR is building a strong family of staff and students in Perth who are visible on the world stage and are contributing to international science.

Over the last year the Centre has had impressive scientific results, including those made by our young PhD students and postdoctoral researchers as they collaborate with colleagues from other world-class institutions.

The SKA is not just about Australia and South Africa, ICRAR is collaborating with institutions across the globe, cultivating studentship, learning, outreach, education and research excellence internationally.

With the site decision, the SKA is now a viable international project in which ICRAR has a very strong role to play.

ICRAR is going through a transformation into its second phase, with the Centre set to capitalise on the scientific return from the SKA precursors, the MWA and the Australian SKA Pathfinder (ASKAP).

As the SKA is changing, ICRAR is also changing as we prepare to make a significant contribution to the design, construction and operation of the telescope.

As well as contributing to the general scientific definition of SKA-low, there are two explicit things ICRAR wants to do for SKA Phase 1 (the first component to be built on both the South African and Australian sites).

The first is to deploy a prototype of the SKA antennas, an activity which ICRAR will assist with.

The second is to contribute to the information technology needs of the SKA, the design of data systems and the extraction of scientific information from large archives.

We trust the future is bright.

SKA-LOW

When early explorers discovered a new country, they would first make a map and then use it to look for interesting rivers, mountains or inlets to explore more closely. In the same way, astronomers often first build a map of the sky and use it to identify celestial objects and points of interest for follow-up and further study. In radio astronomy, this division of the work for an observatory into map building and detailed investigation, requires specialised technologies and capabilities at both low and high frequencies. The SKA will develop low frequency capabilities with extremely wide fields of view (a radio "fish-eye lens") as well as sensitive high frequency dishes and receivers for detailed views of distant objects.

In May 2012 it was announced that the Square Kilometre Array (SKA) radio telescope would be shared, with Australia hosting SKA-low and South Africa, the antennas that are sensitive to the higher frequencies. This decision, which plays to the perceived strengths of each site, is one that will allow the SKA project to realise its scientific ambition.

Having invested early in low frequency radio astronomy, ICRAR is excited about the contribution it can make to SKA-low. In complementary projects over a number of years staff from the Centre's Curtin University node have led developments in new generation sparse aperture arrays, and the construction of the only low frequency SKA precursor, the Murchison Widefield Array (MWA). These projects have given ICRAR extensive experience working at the Australian SKA site.

Over the next few years of SKA pre-construction, ICRAR will look to use its expertise in low frequency technology to build and deploy SKA-low verification antennas. As a founding member of the predominantly European 'Aperture Array Design and Construction' consortium, the Centre will apply its knowledge to development and testing the SKA's new generation of aperture arrays.

ICRAR is also in an excellent position to contribute to the ICT needs of SKA-low, which will be a huge producer of data. The Centre prioritised Information and Communications Technology (ICT) early and, having built the full archive system for the MWA, is skilled in the design of data systems and the extraction of scientific information from archives.

1
ICRAR Deputy Directors Professor Steven Tingay and Professor Peter Hall after receiving the Vice-Chancellor's Award for Excellence and Innovation.
2
A receiver from the Murchison Widefield Array with Professor Steven Tingay (ICRAR), Jesse H Searls (PSI), Derek Carroll (PSI) & Mark Waterson (ICRAR).
3
Curtin University's Vice-Chancellor Jeanette Hacket and MWA Director Professor Steven Tingay with Ministers John Day and Gary Gray at the launch of the Murchison Widefield Array. Credit: Dragonfly Media.

ICRAR Deputy Directors Professor Peter Hall and Professor Steven Tingay received Curtin University's Vice Chancellor Award for Excellence and Innovation.

Achievement
2011–2012

1
An MWA tile begins to take shape in the Murchison Radio-astronomy Observatory.
Credit: Pete Wheeler, ICRAR.

Design

Australia will host SKA-low, an "all-electronic" array with several million stationary antennas sensitive to emissions in the 70 MHz to 450 MHz region. SKA-low will have a very wide field of view (up to hundreds of square degrees on the sky) and the ability to observe in many widely separated directions simultaneously. Traditionally telescopes collect a single set of observations at a time, but the ability to observe in different directions means that the SKA-low collecting area is effectively re-used many times over.

Location

The SKA-low will be built in the Murchison Radio-astronomy Observatory (MRO) in Western Australia's Mid West region. This sparsely populated region is the size of The Netherlands and is virtually free of radio frequency interference, making it a perfect place to build a next generation radio telescope like SKA-low. As a Centre for radio astronomy research based in Western Australia, and as part of the international consortium tasked with designing, building and extracting science from this telescope, ICRAR will play a significant role in SKA-low. Between now and 2016 a number of verification antennas and arrays will be designed, deployed and evaluated, to establish the system design best suited to achieving the science goals as defined by an international system engineering process.

Construction

Between 2016 and 2019 hundreds of thousands of antennas are due to be manufactured and deployed throughout the MRO as part of SKA-low Phase 1, with observing commencing progressively from the early stages. In 2019 Phase 2 of SKA-low construction will begin, with the completed telescope consisting of several million antennas by the time the entire array sees first light in 2025.

Science

The SKA radio telescope will allow us to observe the first objects to shine in the Universe and study the cosmic avalanche of growth that has resulted in our existence some 13 billion years later.

SKA-low will be sensitive enough to allow researchers to study the Epoch of Reionisation, a period in the very early history of the Universe during which the predominantly neutral intergalactic medium was ionised by the emergence of the first stars, galaxies and other objects. By studying reionisation, we can learn a great deal about the process of structure formation in the Universe. We can also find the evolutionary links between the remarkably smooth matter distribution at early times (revealed by studies of the cosmic microwave background radiation), and the highly structured Universe of galaxies and clusters that came afterwards.

With the ability to look in many different directions at once and survey large parts of the sky quickly, SKA-low will also help scientists observe and study objects such as spinning neutron stars called pulsars and fast transient events in which bursts of radio emission appear briefly and without warning.

In 1609, Galileo turned a simple hand-made telescope to the heavens for the first time, a deceptively simple act that heralded a giant leap forward in the history of science and discovery. Now, 400 years later as we continue Galileo's work and build telescopes like SKA-low to probe the first light to appear in the Universe, our scientists will shed light on how stars, galaxies and ultimately we, ourselves came to exist.

ICRAR

1
A remote outback road points the way to the southern sky and the south celestial pole. Credit: John Goldsmith, Celestial Visions.

1
ICRAR's Science and Technology Advisory Committee meet in the ICRAR boardroom.
2
Dr Renu Sharma (Associate Director), Dr Bernard Bowen (Board Chair) and Professor Peter Quinn (Director).

OVERVIEW

ICRAR is truly an international institution, attracting the most talented staff and students from around the world. Though it has only been operating for three years, ICRAR has been acknowledged as one of the top 10 centres of its kind. The Centre has over 70 staff and over 40 postgraduate students across two nodes located at Curtin University and The University of Western Australia.

Through the talents of our researchers, ICRAR has achieved remarkable results in the core areas of science, engineering and information technology as well as practical experience in building the Murchison Widefield Array (MWA) telescope and innovative outreach programs.

The science section has worked with both real and simulated astronomical data to make an enormous contribution to our understanding of the Universe. The Centre's postgraduate students and young postdoctoral researchers have made headlines internationally, with research relating to the search for extraterrestrial life as well as tests of the fundamental laws of physics and the standard model of cosmology. ICRAR astronomers have used existing galaxy surveys to discover that the Milky Way has a couple of "twin" galaxies and to find black holes where no one thought possible. Researchers are also involved in several new surveys that will use the next generation Australian SKA Pathfinder (ASKAP) telescope.

ICRAR's engineers have built and tested equipment for the radio telescopes of the future. They have contributed to projects as diverse as the development of technology for the MWA telescope, the new digital backend for the Parkes telescope, and a system for detecting fast transients deployed at a NASA telescope in California. The engineering team has also developed conical spiral antennas for an experiment to detect the global signal from the Epoch of Reionisation.

The information and communications technology team is finding ways to manage unimaginable volumes of data; capturing, processing and storing information about our Universe on a scale never seen before. They have built the entire end-to-end data archive system for the MWA, from the initial data capture at the telescope to the processing, transport and eventual storage of the information.

In fact, through its Curtin University node, ICRAR has played a huge role in the construction of the MWA overall, an experience that will prove invaluable when the time comes to build the SKA. Led by Deputy Director Steven Tingay, the MWA telescope has been built in the remote Murchison region of Western Australia.

Finally, ICRAR's outreach and education team has worked to share the Centre's exciting research with the world. They have organised countless workshops, talks and other events, linking passionate scientists with school and university students, teachers and the wider public. In addition to these traditional events, ICRAR has developed innovative outreach programs such as the citizen science initiative theSkyNet, which allows people to donate spare computing power to process radio astronomy data. The Centre's guerrilla astronomy nights engage unsuspecting passers by in astronomy and ICRAR's research is featured in hundreds of media articles each year, both nationally and internationally.

ICRAR Director Professor Peter Quinn was named Western Australia's Scientist of the Year at the 2012 WA Science Awards for his role in bringing the SKA to the State.

Achievement
2011–2012

GOVERNANCE AND MANAGEMENT

Governing Board

ICRAR is governed by a competency-based board established under the Joint Venture Agreement and appointed by the State Government.

Dr Bernard Bowen	Chair, Appointed February 2009
Professor Lyn Beazley	Independent member (science education), Appointed February 2009
Professor Brian Boyle	Independent member (radio astronomy), February 2009 – August 2012
Professor Ron Ekers	Independent member (radio astronomy), Appointed November 2012
Mr Phillip Jenkins	Nominated member (by the Dept. of Commerce), Appointed February 2009
Professor Graeme Wright	Nominated member (by Curtin University), Acting representative since June 2011, Appointed May 2012
Mr Graham McHarrie	Independent member (corporate governance), Appointed June 2010
Dr Vanessa Guthrie	Independent member (corporate governance), Appointed February 2011
Professor Alistar Robertson	Nominated member (by The University of WA), February 2009 – November 2012
Professor Tom Spurling	Nominated member (by CSIRO), Appointed February 2009
Professor Robin Owens	Nominated member (by The University of WA), Appointed November 2012

Science And Technology Advisory Committee

Professor Ron Ekers	Chairman, CSIRO
Professor Arnold van Ardenne	ASTRON, The Netherlands
Professor Matthew Bailes	Swinburne University of Technology
Professor Erwin de Blok	ASTRON, The Netherlands
A/Professor Geoff Bower	University of California, Berkeley, USA
Dr Peter Dewdney	University of Manchester, UK
Professor Elaine Sadler	University of Sydney
Professor Tom Spurling	ICRAR Board Member

ICRAR Finance and Audit Committee members

Mr Graham McHarrie	Chair (from June 2010 and member from July 2009)
Mr Dennis Glennon	Member (from November 2011)
Mr Mark Woffenden	Member (from July 2009)

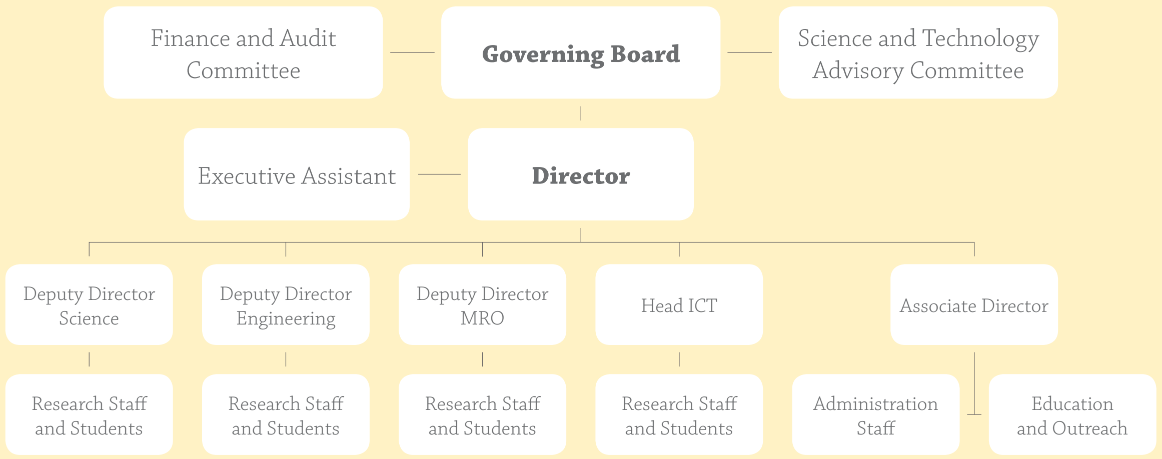
ICRAR IP Steering Committee (from August 2012)

Mr Graham McHarrie	Chair
Mr Paul Kristensen	Member
Ms Jenni Lightowlers	Member
Mr John Stonier	Member
Dr Andy Sierakowski	Nominated member (by The University of WA)
Mr Russell Nicholls	Nominated member (by Curtin University)

Executive Team

Professor Peter Quinn	Director and CEO
Professor Peter Hall	Deputy Director for Engineering
Professor Lister Staveley-Smith	Deputy Director for Science
Professor Steven Tingay	Deputy Director for MRO
Dr Renu Sharma	Associate Director

ICRAR Organisational Structure



Finances

ICRAR is a $105 million Centre, with $20 million committed by the State Government of Western Australia and $85 million cash and in-kind support committed by Curtin University and The University of Western Australia.

Over 70% of ICRAR's budget is allocated to the four research programs and nearly 10% is spent on education and outreach activities. The budget allocation for different ICRAR programs and expenditure as a percentage is shown opposite.

Research Grants

ICRAR has continued its initial success in leveraging the State Government and joint venture funding to win national and international research grants. To date ICRAR has generated an additional $28 million in grants for research projects and activities over the next 5 years.

Growth

ICRAR has grown rapidly to 73 staff and 41 PhD students. As a research organisation ICRAR has a vibrant culture and a good mix of science and technology in its staffing profile. More than half of our staff are astronomers, with engineers and high performance computing specialists making up nearly one third. ICRAR's core programs and projects are progressing on track and ICRAR's outreach and education team have directly engaged with more than 35,000 students, teachers and members of the general public since the organisation launched in September 2009.

To date ICRAR has published a total of 280 high quality refereed publications with 100 publications delivered during the July 2011 to June 2012 period alone. ICRAR has conducted 181 seminars and organised many high profile public talks by eminent astronomers and engineers.

ICRAR has a culture of excellence and is committed to supporting its staff, students and visitors by providing a supportive environment that is conducive to their growth and professional development.

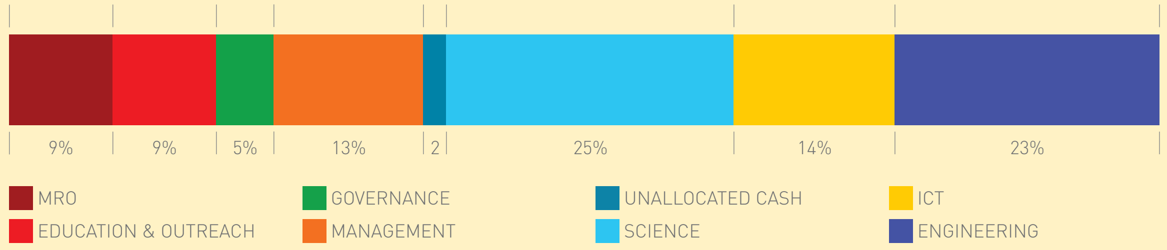
With the announcement of a shared SKA site outcome in May 2012, ICRAR has achieved one of its major objectives of helping Australia host the SKA. ICRAR is now actively participating in the SKA pre-construction phase and has become an important hub of astronomy and engineering activities in Western Australia.

In 2012 ICRAR hosted many important visits, including a visit by the SKA Board and the SKA Project Office. Other meetings and conferences included a SKA-low meeting, a Magellanic Clouds conference, a GAMA meeting, the DIISRTE sponsored SKA Industry Information Forum and the first meeting of the SKA Science Data Processing Consortium. In October of 2012 ICRAR co-sponsored the Women in Astronomy workshop in Melbourne.

Towards the end of 2012 ICRAR received major recognition at the WA Science Awards. ICRAR Director Professor Peter Quinn won the WA Scientist of the Year Award and ICRAR Deputy Director, Professor Steven Tingay was awarded the title of Science Ambassador of the Year. ICRAR's distributed computing initiative, theSkyNet, was also nominated as a finalist in the Science Engagement Initiative of the Year category. Beyond these accomplishments, many other awards have been won by ICRAR staff and students in the period covered by this Year Book.

ICRAR has successfully completed three years of growth and has met all its funding and compliance requirements on time and on target. It is now getting ready for the second phase of ICRAR in 2014–2018.

1
ICRAR budget allocation for programs and expenditure as a percentage.
2
The SKA Board of Directors meeting in Perth.
3
Professor Steven Tingay is named Science Ambassador of the Year at the 2012 WA Science Awards.



Professor Steven Tingay was named Science Ambassador of the Year at the 2012 WA Science Awards.

Achievement
2011–2012

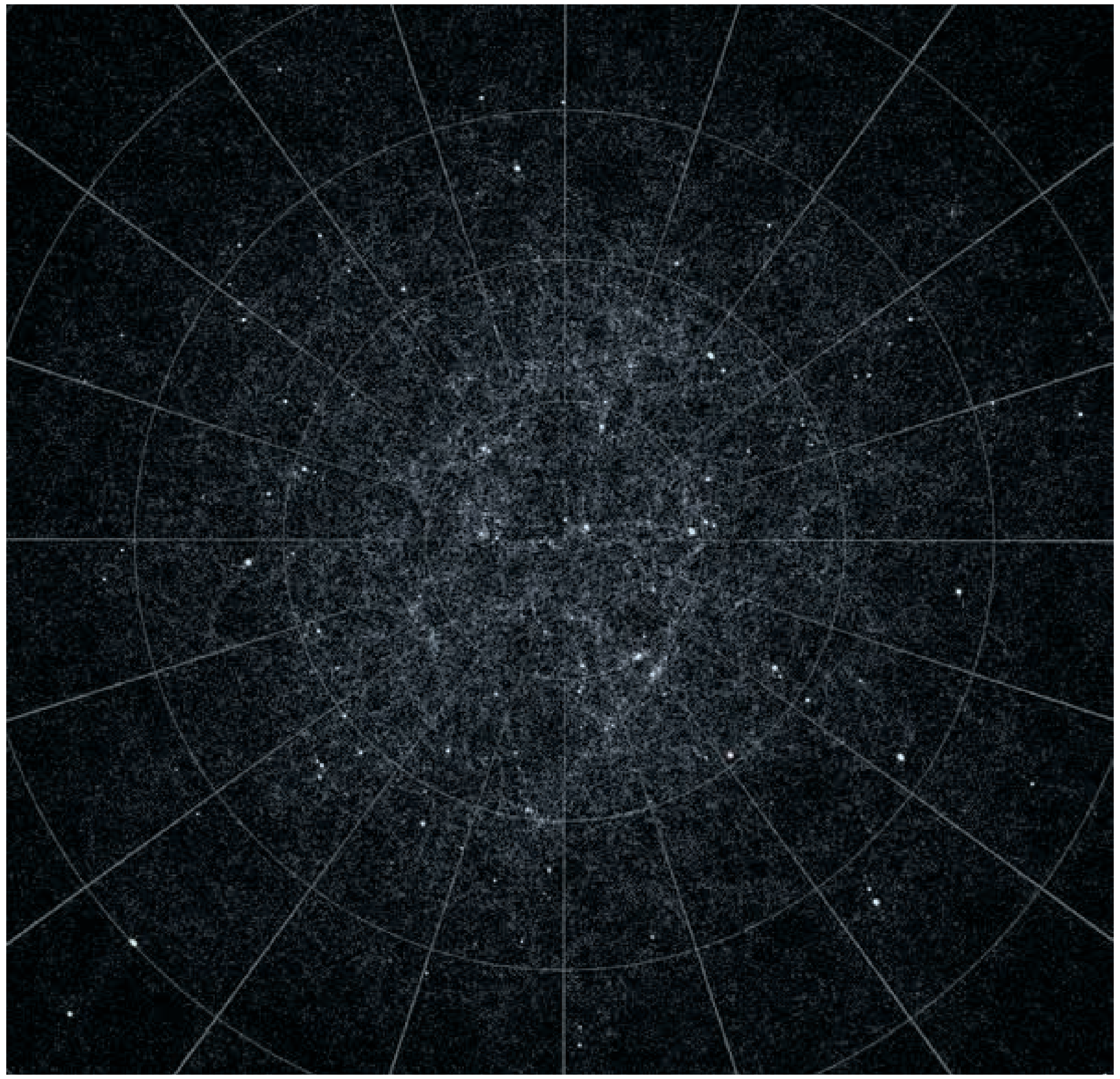
1
A simulated image of a dwarf galaxy forming several billion years ago.
Credit: Dr Alan Duffy (ICRAR), Paul Bourke (iVEC@UWA), Dr Robert Crain (Leiden Observatory).

SCIENCE

SCIENCE OVERVIEW

Through technology and human endeavour, science has grown our understanding, answering many questions and asking many more. Using modern instruments to look beyond the spectrum of visible light we are now able to see much more of the Universe. ICRAR has several key areas of research that relate to the science that will come from observations captured by radio telescopes like the Square Kilometre Array (SKA), the Australian SKA Pathfinder (ASKAP), the Murchison Widefield Array (MWA) and other facilities located around the world.

1
A visualisation created by PhD student Derek Gerstmann of galaxies predicted to appear in the WALLABY survey, based on the semi-analytic simulations of Dr Alan Duffy, and collaborators, and the dark matter Millennium simulation.
2
Professor Lister Staveley-Smith, Deputy Director of ICRAR Science.



The Centre has three key science themes:

GALAXY ASSEMBLY AND EVOLUTION

Understanding the processes that lead to the formation of galaxies and their subsequent evolution is a key goal for modern cosmology and a key science theme for the SKA. Surveys of neutral hydrogen (HI) and emission at other wavebands have been extremely important in understanding the formation, fuelling and interaction processes in nearby galaxies. New surveys and observations with ASKAP and other next-generation radio telescopes will help transform our understanding of galaxies in the more distant Universe. A powerful complement to multi-wavelength studies of galaxies is the ability of ICRAR researchers to understand and model their properties through sophisticated super-computer simulations.

THE VARIABLE UNIVERSE

This theme encapsulates what have become known as 'fast' and 'slow' transients, where the former are events which change their behaviour on timescales of seconds or less (e.g. pulsars and radio bursts), and the latter are objects which appear to change their radio emission, whether by propagation effects or intrinsic phenomena such as black hole accretion, on longer timescales. ICRAR's research interests are based around observations and modelling of supernovae, gamma ray bursts, X-ray binaries, pulsars and other compact sources. This is a science area of considerable potential - the SKA and the pathfinder instruments will explore completely new observational regimes in sensitivity, time resolution and sky coverage.

HIGH ANGULAR RESOLUTION RADIO ASTRONOMY

Creating detailed images of galaxies millions of light years away is a huge challenge for radio astronomers. The detail of an image can be increased by using a larger telescope, but significant engineering problems arise as the size of the telescope increases. However, there is an innovative solution—to simulate one large antenna by connecting an array of smaller antennas using a technique called interferometry. The further apart the individual antennas are, the larger the simulated telescope and the higher the resolution of the final image.

By separating the antennas by thousands of kilometres, the same resolution can be achieved as if using a single antenna thousands of kilometres wide. Combining signals from antennas with large separations in this way is referred to as Very Long Baseline Interferometry (VLBI). ICRAR researchers work with telescopes throughout Australia and around the world to conduct VLBI observations and study distant objects in unprecedented detail.

In the 2011-12 financial year, ICRAR surpassed 100 publications in peer-reviewed journals for the first time.

Achievement
2011–2012

WALLABY/DINGO ASKAP SURVEYS

1, 2
Stills extracted from a visualisation created by PhD student Derek Gerstmann showing galaxies predicted to appear in the WALLABY and DINGO surveys.
3
A Phased Array Feed (PAF) on an ASKAP dish located at the Murchison Radio-astronomy Observatory.

A survey that will catalogue over half a million galaxies and create a map of the sky and another that will look back four billion years in time are two of the many exciting science projects being undertaken at ICRAR. The two surveys, called WALLABY and DINGO, have both been awarded science survey status on the next-generation Australian SKA Pathfinder (ASKAP) telescope and are due to start in 2013. They are among 10 science projects collectively awarded 75 per cent of the time on the telescope in its first five years of operation.

The naming of the WALLABY survey comes from Widefield ASKAP L-band Legacy All-sky Blind survey and will be led by ICRAR Deputy Director Lister Staveley-Smith and CSIRO OCE Science Leader Baerbel Koribalski. DINGO stands for Deep Investigation of Neutral Gas Origins and will be led by ICRAR Research Associate Professor Martin Meyer.

Both surveys will study the neutral hydrogen gas (HI) that is the building block of stars and galaxies. WALLABY will survey the whole sky while DINGO will spend more time on smaller sections. It is hoped they will be able to start when the ASKAP test array BETA comes online in mid 2013 and ramp up at the end of 2013 when the telescope is operational.

WALLABY

WALLABY will survey the whole sky in the southern hemisphere, cataloguing over half a million galaxies and creating a map of the sky in a form of cosmic cartography. Currently, the best radio frequency all sky survey conducted in the southern hemisphere is HIPASS, a survey of about 5,000 galaxies observed with the Parkes telescope in New South Wales. WALLABY will be vastly superior to HIPASS, surveying 100 times more galaxies and observing deeper and at a higher resolution and sensitivity than ever before.

The project will produce a general galaxy catalogue and will teach us about galaxy formation, how galaxies get their gas and how groups are formed. The sheer number of galaxies in the survey will also lend itself to statistical analyses such as comparing how galaxies form in different environments.

WALLABY will survey out to redshift 0.26, which corresponds to a little under three billion years ago, although most of the galaxies it looks at will be much closer than this. It will observe each section of the sky for eight hours and, with ASKAP having a field of view of 30 square degrees, will require about 1200 pointings to cover the whole sky.

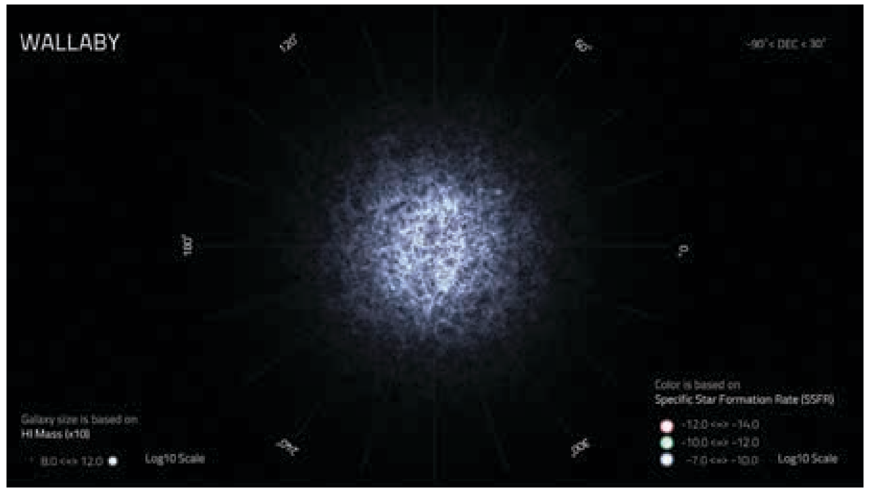
DINGO

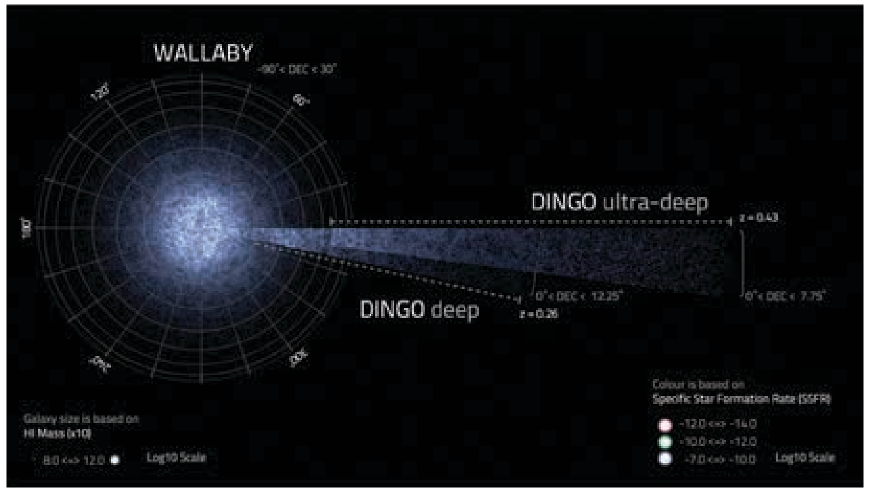
DINGO will be a much finer survey than WALLABY and will look at only a small number of regions but for a very long time. It will observe the same areas of the sky again and again, collecting data from five regions for 500 hours and two regions for 2,500 hours. This extended survey period means DINGO will be able to see further back in time than WALLABY to redshift 0.43, which corresponds to roughly four billion years ago — or about a third of the history of the Universe. It will also be able to detect much fainter galaxies than WALLABY.

DINGO will be focused on questions of galaxy evolution and has three main themes; how the global HI content of the Universe has changed over time, how the distribution of that gas has changed and how these changes relate to data available at other wavelengths such as star formation and dust.

The sections of the sky DINGO will look at will be largely driven by observations at other wavelengths, such as the Galaxy And Mass Assembly (GAMA) survey. By surveying regions that have already been studied at optical or infrared wavelengths, the galaxies studied are those with the greatest potential for scientific discovery at radio wavelengths.

The WALLABY and DINGO surveys will gather an unprecedented amount of data. How to manage, transport, condense and analyse such large volumes of information represents a significant challenge for astronomers and high performance computing experts.





Once a telescope has observed the sky, the information gathered is assembled into "cubes". A cube has three axes; for cubes of radio astronomy data the first two axes correspond to the coordinates system of Right Ascension (RA) and Declination (Dec), giving a location of the source in the sky. The third axis relates to the frequency, which can be converted to velocity to see how fast galaxies are moving, how fast they are rotating and how far away they are.

For ASKAP, cubes of data will be over one terabyte in size, which means trawling through this data looking for sources is impossible without some sort of automated process that can sift through the data, ignoring "noise" and accurately identifying as many actual sources as possible.

PROFILE
PROFESSOR SIMON DRIVER

'You've got hot and cold gas, dust, stars and dark matter and it's the interplay of these components that leads to galaxy evolution.'

Simon Driver
Research Winthrop Professor

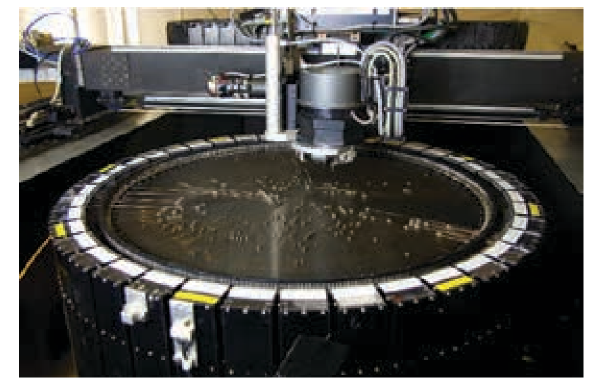
Simon Driver knew he wanted to be an astronomer the day he listened to a classmate give a talk about the planets at his primary school aged 11. "I remember sitting there hearing his talk, being quite spellbound, and afterwards walking around the playground with him just talking about the planets again and again and again," he said. "I went home to my parents and said I wanted to be an astronomer and of course they thought it was one of those crazy ideas that I'd grow out of and I guess I never did."

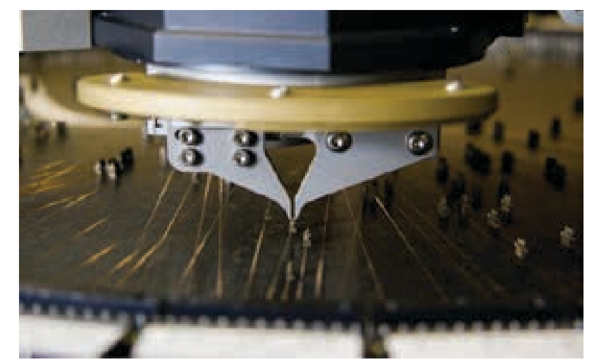
Today, Professor Driver leads the Galaxy and Mass Assembly (GAMA) survey, a catalogue of 300,000 nearby galaxies and currently the largest census of galaxies in the southern skies. "It's pretty much what it says on the wrapper, we're trying to understand how the mass in the Universe formed into galaxies and how they have evolved since," he said. "There's a whole variety of science questions one can take from there but the one I'm most interested in at the moment is trying to understand the diversity of galaxies we have in the nearby Universe. We have grand design spirals, ellipticals and irregulars, some of which have internal structures such as nuclei, central bulges, discs, bars and other inexplicable features. Perhaps they're each a marker of a different kind of formation process —a spherical bulge might be an indicator of galaxies grown by merging, a disk might be an indicator of gas falling in etc."

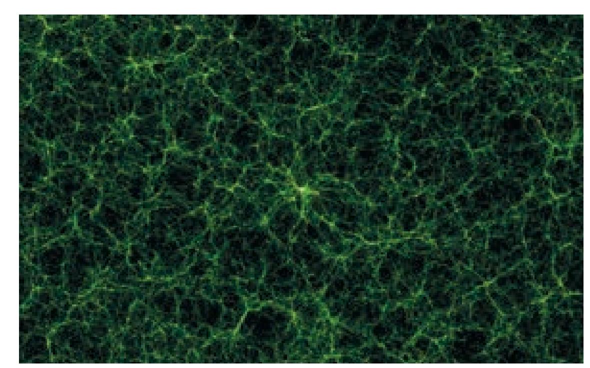
Professor Driver said GAMA was gathering information on multiple telescopes and at all wavelengths. "We have time allocated on three ground-based optical telescopes, two radio arrays and three space missions which together are surveying the same regions of sky from ultraviolet to radio wavelengths," he said. "To some extent we've been stalled on trying to understand galaxy formation for 80 years and one of the reasons for that is that astronomers tend to be quite myopic, working in one wavelength range for their entire careers. The problem is that galaxies are so complicated, you've got hot and cold gas, dust, stars and dark matter and it's the interplay of these components that leads to galaxy evolution. To look at that you have to look across the full wavelength range and that's never been done on such a large scale until now."

WIGGLEZ CONFIRMS THE BIG PICTURE OF THE UNIVERSE

We know that stars group together to form galaxies, galaxies clump to make clusters and clusters gather to create structures known as superclusters. At what scale though, if at all, does this Russian doll-like structure stop?







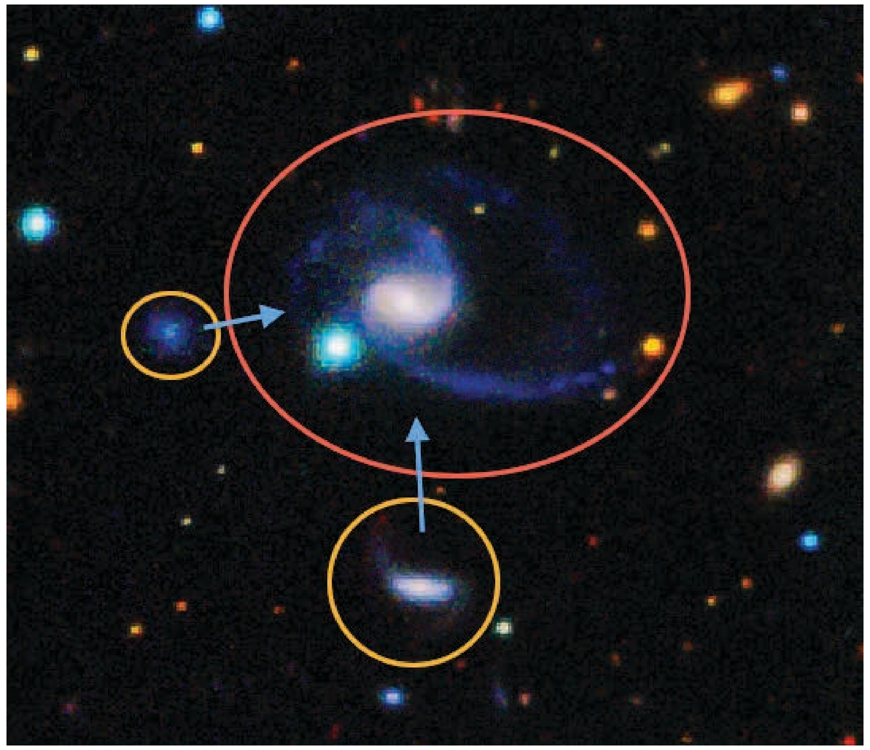
1
PhD student Morag Scimgeour.
2, 3
The 2dF instrument, one of the most complex pieces of astronomical equipment ever built. It's 400 optical fibres are positioned by an incredibly accurate robotic arm. The 3.9 metre Anglo-Australian Telescope observes distant galaxies before the optical fibres of the 2dF instrument feed the light from each into one of two spectrographs ready for analysis. Credit: Barnaby Norris.
4
A slice from the simulation 'GiggleZ' which complements the WiggleZ survey showing large scale structure in the Universe. Credit: Greg Poole, Swinburne University (Centre for Astrophysics & Supercomputing).

Cosmologists agree that on small scales (tens of millions of light years), matter in the Universe is highly clustered but what happens on larger scales is a question that has been debated for decades. Some astronomers have proposed that the Universe is a fractal, with this clustering continuing forever but if this were the case it would require a complete rethink of the standard model of cosmology.

As part of the 'The Dark Universe' theme of the ARC Centre of Excellence for All-sky Astrophysics (CAASTRO), PhD Student Morag Scrimgeour decided to test the homogeneity of the Universe, or the amount of clustering, at these large scales. She used data from WiggleZ, a survey conducted on the Anglo-Australian Telescope and one of the largest galaxy surveys to date with over 200,000 galaxies.

Ms Scrimgeour found that clustering decreases on larger scales to the point where it eventually reaches zero, reaffirming the standard model of cosmology. By the time you reach distance scales larger than 350 million light years, matter is distributed extremely evenly across the Universe, with little sign of fractal-like patterns.

1
SUPA Advanced Fellow
Dr Aaron Robotham
2
One of the Milky Way's twins—GAMA202627—with its two companions.
Credit: Dr Aaron Robotham (ICRAR/St Andrews) using GAMA data.



THE MILKY WAY NOW HAS A TWIN (OR TWO)

Research that found the Milky Way had at least two 'twin' galaxies generated so much interest it was picked up by over 200 media outlets worldwide.

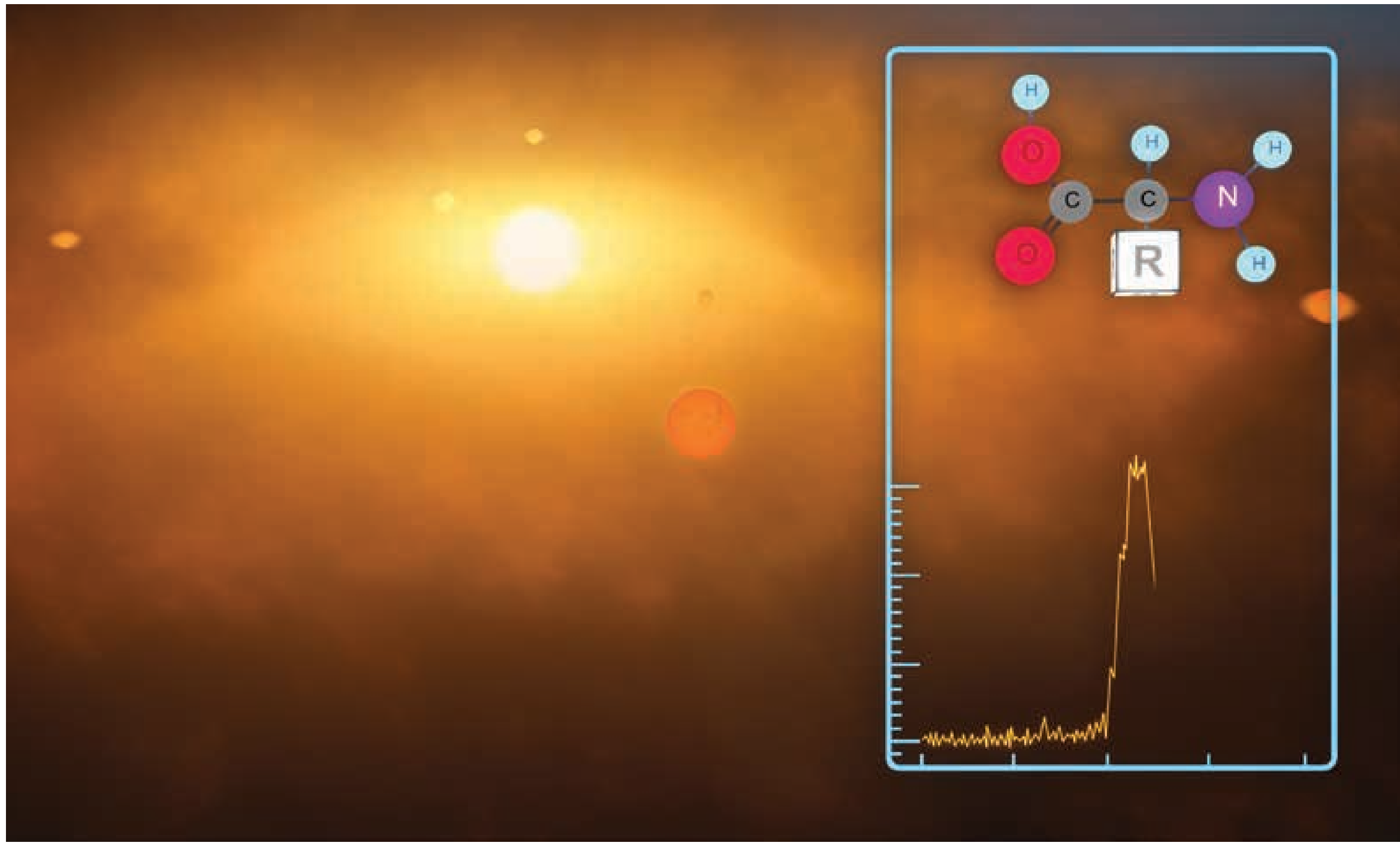
The Milky Way has two large satellite galaxies, the Large Magellanic Cloud and the Small Magellanic Cloud. This pair of orbiting galaxies is a favourite with southern hemisphere skywatchers because, away from city lights, they can easily be seen with the naked eye. But no other galaxy had been found to have the same companions as ours, until now.

Computer simulations predict that having these two orbiting galaxies is very rare, but not so rare that we shouldn't find some. In fact, according to the simulations, a galaxy the size of the Milky Way should have two close satellite companions a couple of per cent of the time. So are the simulations and therefore our understanding of cosmology wrong or is the Milky Way just really lucky?

SUPA Advanced Fellow Aaron Robotham used a sample of about 110,000 galaxies from the GAMA survey to find out if having two satellite galaxies was standard or if the Milky Way had just won the lottery. He discovered that galaxies the size of the Milky Way have two large orbiting galaxies, such as the Large and Small Magellanic Clouds, about three per cent of the time, in line with what the simulations had predicted. Galaxies have just one orbiting galaxy a little over 10 per cent of the time.

> 'Of the hundreds of thousands of galaxies surveyed, two systems were almost exactly like the Milky Way.'

So there is nothing broadly wrong with our understanding of cosmology, the Milky Way is just very lucky. And while the Milky Way might be rare, we are not alone, with Dr Robotham and his colleagues finding 14 galaxy systems similar to ours. Of the hundreds of thousands of galaxies surveyed, two systems were almost exactly like the Milky Way — our galactic "twins" in the Universe.



1
Radio telescopes can detect molecules that might indicate life in distant star systems.
Credit: Swinburne Astronomy Productions and the SPDO.
2
PhD Student Hayden Rampadarath.

THE SEARCH FOR LIFE ON OTHER PLANETS

Perhaps one of the greatest questions in astronomy research, and in life, is whether we are alone in the Universe. PhD Student Hayden Rampadarath and his supervisors are helping to answer this question through his involvement in one of the first targeted searches for life outside our Solar System.

Hayden's research is in widefield Very Long Baseline Interferometry (VLBI), a process of linking telescopes over large distances, often separated by thousands of kilometres. Part of his work uses VLBI to find star-forming regions and study stars and their evolution. But VLBI also happens to be very useful in the search for extraterrestrial intelligence (SETI) because linking telescopes over great distances in this way helps to exclude any interference from Earth that might look like SETI signals. It might sound like the stuff of science fiction but Hayden has been able to develop a new technique for using VLBI to search for life outside of our Solar System.

In the past, SETI searches were always done on broad sections of the sky. Now, astronomers have a good idea about where to look for intelligent life, thanks to a Kepler Space Observatory Mission list of over a hundred planets outside our Solar System, which are in or near the habitable zone and are candidates for supporting life.

Hayden and his colleagues used their new technique to search for life near Gliese 581, a star that has caused a lot of excitement over the years because it's thought to have at least one planet in the habitable zone. The survey failed to find any evidence of aliens but it did prove that the technique works. Hayden's research is set to be very important for the SKA in the future because 'Are we alone?' is one of the big questions the telescope aims to answer.

BLACK HOLES AND GLOBULAR CLUSTERS

1, 2
Globular cluster M22 and a radio telescope close-up image of the black holes discovered within. Credit: M22 image, Hunter Wilson. Black holes image, A/Prof Jay Strader (Michigan State University and the Harvard-Smithsonian Centre for Astrophysics).

Research Fellow Dr James Miller-Jones and his colleagues caused a global stir when they discovered two black holes near the centre of a globular cluster, a finding which contradicted the widely held belief that they should contain only a single black hole.

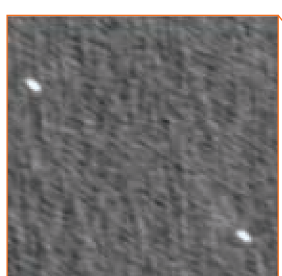
So far two types of black holes have been observed by astronomers, stellar mass black holes with three to 30 times the mass of the Sun and supermassive black holes with a million or more times the mass of the Sun (and found at the centre of galaxies). This leads many scientists to believe that intermediate sized black holes with between 30 and one million times the mass of the Sun should also exist and for this reason Dr Miller-Jones and his collaborators set out to look for intermediate black holes in objects known as globular clusters.

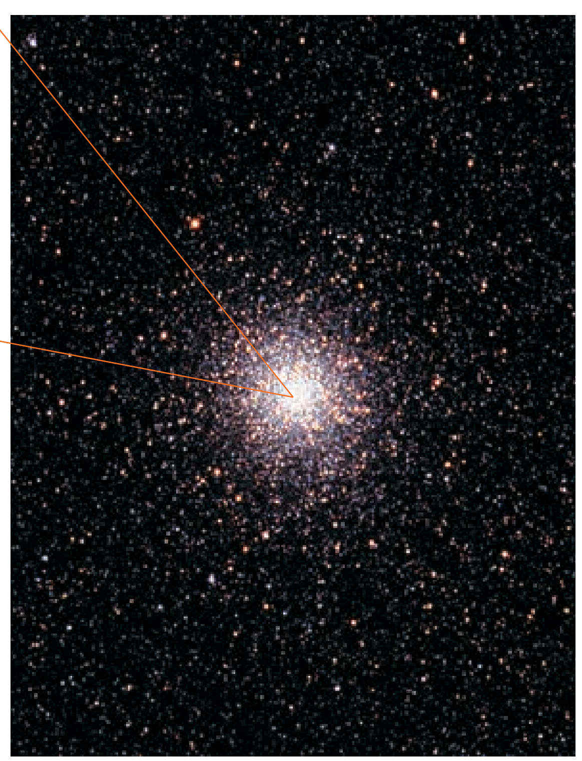
Hunting for black holes isn't trivial — it is not easy searching for something you cannot see directly. These elusive and extreme objects are usually studied by observing the effects they have on surrounding stars or by detecting the signature of gas as it falls towards the black holes event horizon. Dr Miller-Jones used this second method to look for black holes at the centres of three globular clusters in the Milky Way and also one in our nearest neighbouring galaxy of Andromeda.

Unfortunately this did not reveal any intermediate black holes but the observations did detect a couple of unexpected objects located within a few light years of each other, near the centre of one of the globular clusters within our own galaxy. These turned out to be two stellar mass black holes, 10-20 times the mass of the Sun.

The discovery was exciting in itself because the black holes were the first to be found in a globular cluster belonging to the Milky Way. But what was even more interesting is that prior to this result no one thought two black holes could exist in the same globular cluster without gravitational interactions ejecting the additional blackholes.

The next step for Dr Miller-Jones and his collaborators will be to analyse the black holes in more detail in an effort to learn more about them and their properties. Ultimately this will lead to a better understanding of how these objects have formed and evolved over time.





Dr James Miller-Jones was a co-author on the paper 'Two black holes in the globular cluster M22' that was published in the journal Nature in October 2012. The discovery caused a rethink of our understanding of how globular clusters work.

Achievement 2011–2012

V-FASTR - THE SEARCH FOR TRANSIENTS

1
The VLBA is a system of ten radio telescopes spanning thousands of kilometres. Credit: Image courtesy of the SeaWiFS Project NASA/GSFC and ORBIMAGE.

In 2007, a paper was published on a mysterious burst of radio emission observed by the Parkes telescope in New South Wales. All indications were that this burst had come from an object well outside our galaxy, but researchers could not pinpoint where in the sky it had come from or even verify that it was astronomical at all.

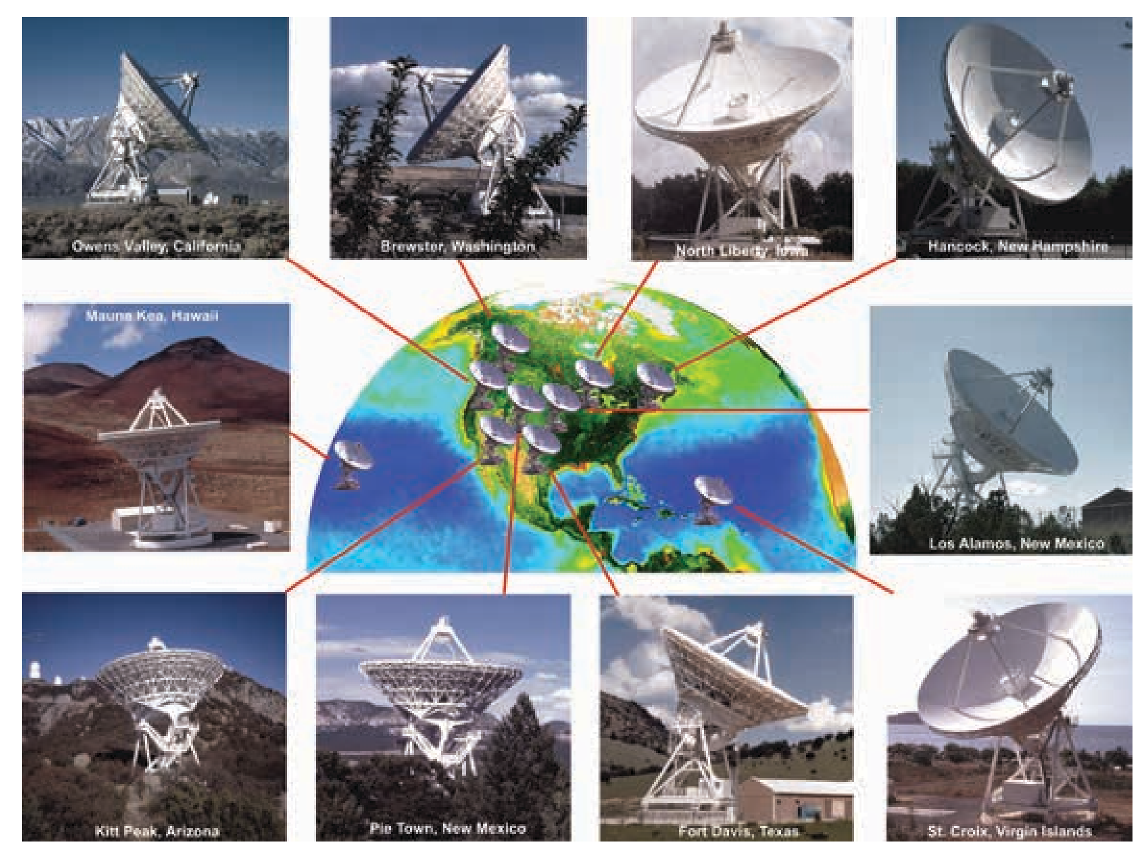
This mysterious detection got ICRAR Deputy Director Steven Tingay thinking about how to detect similar bursts and figure out which galaxy they had originated from. He realised that if there was a way to detect and localise more of these events they could teach us about the material between the burst and Earth, called the intergalactic medium.

According to legend, Nikola Tesla came up with the idea of alternating current as he was going for a walk, while Archimedes' flash of inspiration came while he was in the bath. The lightbulb moment for Professor Tingay came when he was sweeping and raking in the backyard and thinking about the number of telescopes that would be needed to look for these bursts of radio emission. Professor Tingay knew the best way to look for these events would be to use Very Long Baseline Interferometry (VLBI), a process of linking telescopes over thousands of kilometres. But his eureka moment was realising that software that had been written a couple of years earlier could be adapted to process ordinary VBI data and simultaneously look for these emission bursts.

So the V-FASTR experiment was born. Professor Tingay led the modification of software already installed on the Very Long Baseline Array in the United States, a network of 10 telescopes scattered over 8,000km, to add in this extra processing step and look for bursts of radio emission. Because it happens simultaneously alongside existing VLBI processing, the search for the bursts runs 24 hours a day, seven days a week and costs nothing.

V-FASTR has now been running for a couple of years and, although a burst is yet to be detected, there have been some marginal candidates. As time goes on, the researchers are refining the constraints on the event rate and the system is currently being upgraded to make it more sensitive. As soon as a burst is detected, it will be pinpointed in the sky to a millionth of a degree precision, allowing the galaxy it emanated from to be calculated.

In the meantime, the group who published the first result from the Parkes radio telescope have detected several more bursts. It appears there is little doubt they are extragalactic and there is clearly a lot more to discover in this very new area of astronomy.



THE EPOCH OF REIONISATION

'BIGHORNS is designed to be portable and can be deployed at different places to find the best location to observe from.'

Astronomers have a good idea about what happened at the very beginning of the Universe, the Universe's recent history and what is happening today. But there is a time when the first stars and galaxies were forming that we know almost nothing about. This missing section of the cosmic history book is called the Epoch of Reionisation and is part of a time often referred to as the "dark ages", because optical telescopes are of little use in studying it.

Led by Research Fellow Randall Wayth, ICRAR is assisting the ARC Centre of Excellence for All-sky Astrophysics to build an experiment called BIGHORNS that hopes to answer some of the questions being asked about the cosmology of this mysterious time. Using an innovative spiral antenna design, BIGHORNS will study neutral hydrogen gas, detecting the signal from a period when the first stars and galaxies were forming.

Unlike most radio astronomy experiments, BIGHORNS is designed to be portable and can be deployed at different places to find the best location to observe from. Already the system has been tested at Muresk, 90km east of Perth in the Avon Valley but the experiment will ultimately collect data from a very remote location like the Murchison Radio-astronomy Observatory (MRO) where there is limited radio frequency interference.

The Epoch of Reionisation is also one of four key science goals for the Murchison Widefield Array (MWA) but BIGHORNS and the MWA will approach the problem in very different ways. BIGHORNS will look at the global average signal while the MWA will study finer details over a smaller section of the sky.

A test BIGHORNS system has been deployed at Muresk, 90km east of Perth in the Avon Valley.

Achievement 2011–2012

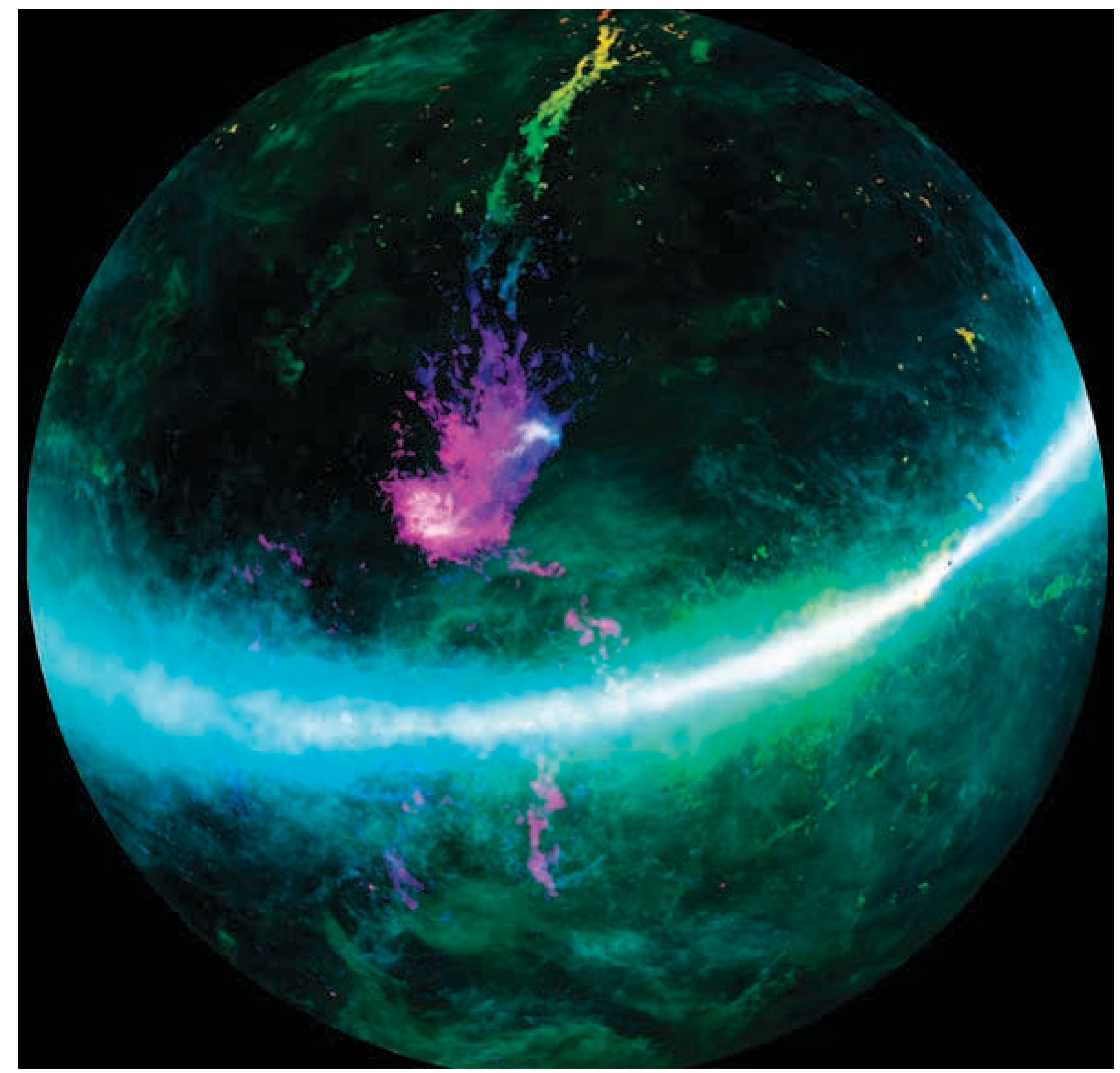
THE GALACTIC NEIGHBOURHOOD

ARC Future Fellow Kenji Bekki has made some remarkable astronomical discoveries — without once ever needing to use a telescope. This is because his research studies the Universe through simulations, large 3D computer models of galaxies and globular clusters.

By creating simulations that are very close to the real Universe, astronomers are able to study phenomena that would be impossible to observe directly with a telescope. For instance, Professor Bekki's favourite objects to study are the Large Magellanic Cloud and the Small Magellanic Cloud, a pair of satellite galaxies very close to the Milky Way that can be seen with the naked eye. The Large Magellanic Cloud has a bar structure at its centre but it's difficult to determine how this shape was formed using a telescope alone because we can only take a snapshot of how the galaxy is today.

By running a simulation backwards, it is possible to model the interactions between the Large Magellanic Cloud, the Small Magellanic Cloud and the Milky Way over time and study the evolution of this bar shape structure.

The most important "ingredient" in the simulations is the gravitational interaction between stars and gas but the models get more complex every year. Today, Dr Bekki's simulations are very sophisticated and include factors such as gas dynamics, star formation, chemical evolution, dust evolution and supernova feedback effects.



1
Hydrogen gas in the Milky Way below the large and small Magellanic Clouds and the Magellanic Stream.
Credit: S. Janowiecki (Indian University), N. McClure-Griffiths (CSIRO), D.J. Pisano (West Virginia University) and the GASS team.

STUDENT HIGHLIGHTS

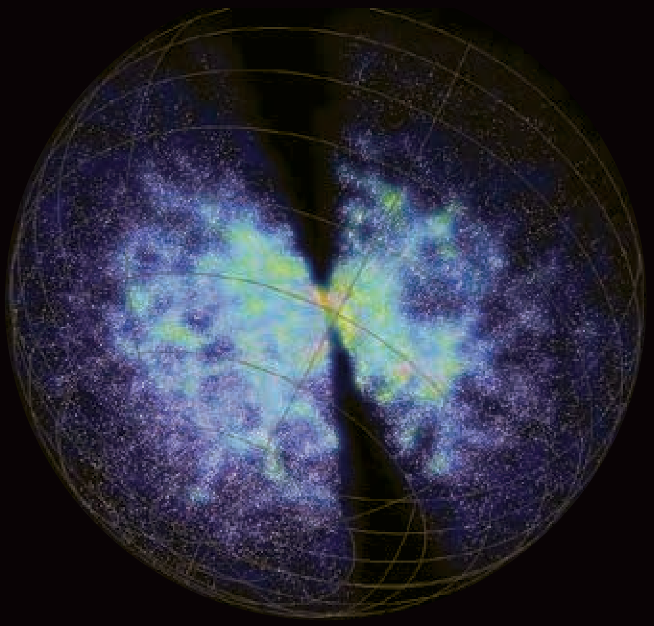
Dr Florian Beutler, PhD Graduate

THESIS: COSMOLOGY WITH THE 6dF GALAXY SURVEY

Florian Beutler's research made headlines around the world when he made one of the most accurate measurements ever of the Hubble constant. His measurement tells us how fast the Universe is expanding and can be used to calculate the age of the Universe. They also provide clues as to how it might end.

Florian's research statistically analysed the distributions of galaxies in the 6dF Galaxy Survey, a catalogue of over 120,000 galaxies. As well as measuring the Hubble constant, he tested Einstein's theory of general relativity on cosmic scales, finding that the theory held true.

Astronomy was a new challenge for Florian, who studied particle physics in Germany before coming to Western Australia. He initially accepted a two-month internship with ICRAR and liked Perth so much he decided to stay and do his PhD. Florian handed in his thesis in September 2012 and has jetted off to the US to take up a prestigious postdoctoral position at the University of California, Berkeley.



1
The 6dF Galaxy survey data.Each dot is a galaxy with Earth at the centre of the sphere.
Credit: Dr Chris Fluke (Centre for Astrophysics & Supercomputing, Swinburne University of Technology.

Jacinta Delhaize, PhD Student

THESIS: PROBING GALAXY EVOLUTION IN INTERMEDIATE-REDSHIFT GALAXIES USING STACKING TECHNIQUES

Jacinta Delhaize's research into galaxy evolution has taken her around Australia and to four other continents. After growing up in Perth, Jacinta completed part of her research at Oxford University in the UK and has also been to Germany, the Netherlands, South Africa and Chile as part of her studies. She gathered data for her research on the Parkes radio telescope made famous by the film 'The Dish' and has travelled throughout Western Australia encouraging high school students to get involved in science.

Jacinta studies how galaxies formed after the Big Bang and how they have changed over time. Using telescopes like Parkes, she observes neutral hydrogen gas, which is important in galaxy evolution because it forms stars and is considered the building block for galaxies.

Astronomers do not know how the hydrogen gas content of galaxies has changed over time. They can look back through cosmic history by studying galaxies further away but it is hard to do because hydrogen gas emits a very weak signal and most existing radio telescopes are limited in how far they can see. To overcome this challenge, Jacinta is developing a technique called "stacking" that involves studying thousands of galaxies and averaging the signal together instead of just looking at one galaxy for a long time.

Dr Kevin Koay, PhD Graduate

THESIS: INTERSTELLAR AND INTERGALACTIC SCATTERING AS ASTROPHYSICAL PROBES

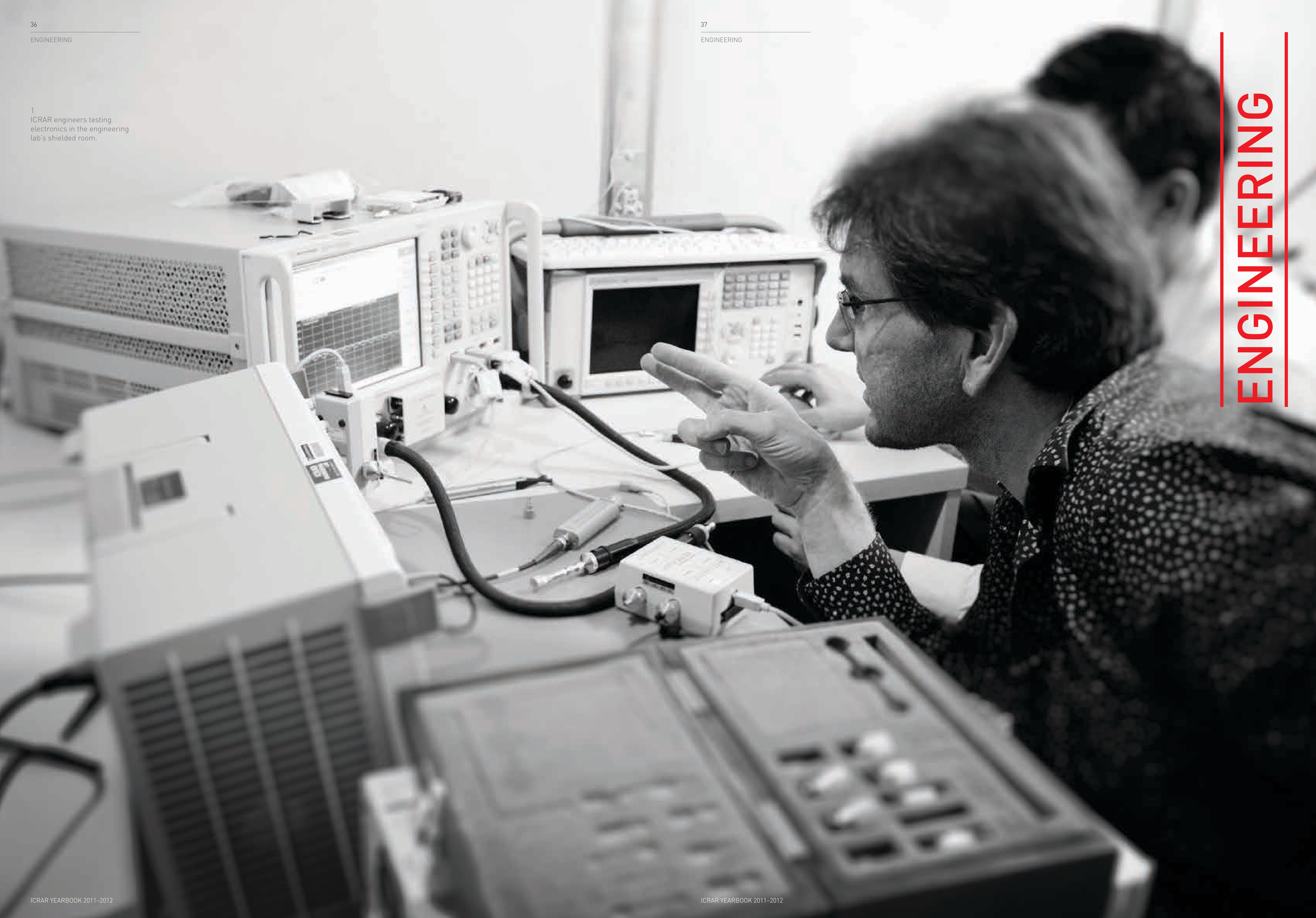
Look up at the sky on a clear night and you will see that stars appear to twinkle because of the effects of the Earth's atmosphere. Kevin Koay's research looked at very compact distant objects in the Universe, such as objects associated with supermassive black holes, which twinkle just like stars. But unlike stars, which appear to twinkle because of the Earth's atmosphere, the twinkling of these very compact objects is because of the gas in our own galaxy and occurs mainly at radio frequencies.

By studying the twinkling of these objects, Kevin was able to estimate their sizes at a much sharper resolution than is possible with a ground based telescope. For the first time, he and his colleagues used this twinkling as an "interstellar telescope" to study the cosmic expansion of the Universe, the evolution of supermassive black holes, and the intergalactic gas between galaxies.

Kevin's work led to him being honoured with a Young Scientist Award by the International Union of Radio Science and he presented a paper at the union's general assembly in Istanbul in 2011. Kevin handed in his thesis in August 2012 but his research continues to inform the design of ASKAP and the SKA, helping to maximise the science outcomes of these telescopes. In particular, he is now looking at how radio signals are distorted as they pass through the interstellar and intergalactic gas and how this affects the way we observe transient sources with these telescopes. Kevin is also a co-investigator on two of the first surveys to be done by ASKAP once it is fully operational, the fast transients survey CRAFT and the variables and slow transients survey VAST.

1
ICRAR engineers testing electronics in the engineering lab's shielded room.

ENGINEERING



1
Dipole antennas of the Murchison Widefield Array ready to be placed in position.

ENGINEERING OVERVIEW

ICRAR has the distinct advantage of having both astronomy and engineering skills within the one institution. The Centre has dedicated engineering staff and facilities co-located with other researchers, leading to excellent crossover and improved research outcomes for all involved. This rare skill set has led to many cross disciplinary training opportunities for our staff and students, which provide well for the skills needed for the next generation of telescopes.

ICRAR Engineering has also cultivated strong links with local and international industry, providing opportunities for involvement in the current work towards the SKA and its precursors. The Centre has its own engineering lab with extensive facilities for prototyping, engineering research and design and testing. With 13 technical and engineering staff and approximately 10 technical astronomers, the engineering lab supports activities across ICRAR.

The engineering program focuses on a number of key areas for radio astronomy in Australia:

SKA-LOW

The low frequency aperture arrays of the SKA require major research and testing in antenna design and electronic systems engineering. The ICRAR engineering group is part of a consortium helping develop the required technologies for SKA-low ahead of its construction in Australia.

MURCHISON WIDEFIELD ARRAY (MWA)

The Murchison Widefield Array is the low frequency precursor to the SKA. The telescope launched at the end of 2012 and will begin full science operation in mid 2013. ICRAR engineering has been heavily involved in the MWA, from systems design through to construction and site support.

ELECTROMAGNETIC COMPATIBILITY (EMC)

Protecting the extremely radio quiet environment of the Murchison Radio-astronomy Observatory (MRO) is one of the most important aspects of ICRAR's engineering work. ICRAR has world-class facilities, enabling characterisation and testing of any equipment intended for the MRO, ensuring that the infrastructure developed for the telescopes does not interfere with the pristine conditions for which the site has been chosen. In addition, ICRAR is able to bridge the gap between radio astronomers and the established EMC engineering community, and to help in the drafting and implementation of appropriate standards for systems installed at the MRO and other radio observatories.

RADIO ASTRONOMY INSTRUMENTATION

ICRAR engineers are either themselves astronomy researchers, or work closely with astronomers. The Centre has developed a variety of new instrumentation in high angular resolution astronomy (VLBI), high time resolution radio astronomy (fast transients), and in global Epoch of Reionisation observations. These observations are described throughout this Yearbook and their success highlights the value of the ICRAR's cross-disciplinary approach.

SKA-LOW VERIFICATION

1
A potential design for the millions of SKA-low antennas. Credit: Swinburne Astronomy Productions/SPDO.
2
Visiting engineers from Italy help ICRAR engineers construct a prototype SKA-low antenna for testing.

A large contributor to the SKA being awarded to Australia was ICRAR's work in aperture array development and verification. ICRAR became involved in aperture array research when Deputy Director Peter Hall moved to Western Australia from his previous job as the international project engineer for the SKA. He realised that no one was doing enough work in the area of sparse aperture arrays for SKA-low — so the Centre became the only non-European participant in the Aperture Array Verification Program of the SKA preparatory phase, called PrepSKA.

PrepSKA officially wound up in March 2012 and the aperture array verification work has now moved to the SKA pre-construction phase. After making a major contribution to the Aperture Array Verification Program, ICRAR is now a founding member of the Aperture Array Design and Construction consortium, with partners including ASTRON in the Netherlands, Cambridge, Oxford and Manchester universities in the United Kingdom, and Italy's national astrophysics institute, INAF. The consortium is responsible for taking both the sparse aperture arrays for SKA-low and the dense aperture arrays that will be built in South Africa through the stages of technical development and astronomical demonstration.

The work of this consortium will be heavily slanted towards low frequency technology, with roughly 85 per cent of the consortium's resources spent on SKA-low verification over the next few years. The remaining work being done by the European partners is advancing the less mature dense aperture array technology for SKA-mid, although this is a more distant target because dense aperture arrays, if selected as an SKA technology, will not be built in South Africa until Phase 2 of the SKA.

ICRAR has the lead role in deploying the SKA-low verification systems in the SKA pre-construction phase, which will start at the beginning of 2013 and run until 2016 or 2017. To date the Centre's researchers have worked with colleagues at Cambridge University and ASTRON to get a small test system in place at the Murchison Radio-astronomy Observatory (MRO) in Western Australia. This system of 16 antennas sits beside the MWA and is called the Aperture Array Verification System 0.5, indicating it follows the very first version built at European sites, and is on the path to bigger SKA verification projects to be built at the MRO when SKA site access is approved.

ICRAR has taken a technology-agnostic approach in the development of SKA-low and is involved in both hands-on projects and system design studies. The Centre has completed an important system analysis looking at the choice of antenna for the telescope and, in particular, whether SKA-low will have to use one or two antennas to cover the 70-450MHz frequency band. Other developments include robust, low-noise amplifiers for SKA-low active antennas, and prototype solar power solutions for SKA-low stations.

ICRAR has also succeeded in building and characterising high-performance conical spiral antennas for low frequency radio astronomy. An investigation has shown that although these antennas are unlikely to be the best deployed solution for SKA-low, they are invaluable in helping to characterise production antennas and have other applications in low frequency radio astronomy, such as in studying the Epoch of Reionisation, a time early in the history of the Universe when the first stars and galaxies were forming.

ICRAR solidified its contribution to SKA-low in September 2011 when it hosted a workshop attended by over 100 senior researchers from around the world. This workshop, called "The Path to SKA-low", discussed the science, technical design, performance and implementation plan for low frequency aperture arrays in Phase 1 and Phase 2 of the SKA.

Achievement 2011–2012

PROFILE DAVE EMRICH

'Working as a firefighter makes you keenly aware of safety issues, which is important on the MRO as well.'

Dave Emrich
MWA Commissioning Engineer

Dave Emrich is no stranger to the challenges of working on a remote site. In his job overseeing the building of the Murchison Widefield Array (MWA) telescope, the engineer splits his time equally between Perth and the Murchison Radio-astronomy Observatory (MRO) in outback Western Australia. "You go to reach for something that you've normally got beside you in a lab and it's not there," Mr Emrich said. "You've got to come up with a way of working around a missing tool or a broken machine because the alternative is a day trip to Geraldton at the very least. Whereas working in a laboratory environment you can usually get something couriered overnight if you've broken something or lost something. You need to be a little bit more self-sufficient."

Mr Emrich's role requires a handle on engineering management, systems engineering and, perhaps most importantly, an ability to find faults and diagnose problems no one has ever seen before.

But it is the creative problem solving that comes with working on such a cutting edge project that is one of the most rewarding parts of the job for Mr Emrich, along with being able to earn the respect of leading radio astronomers from around the world.

Mr Emrich previously worked in electronic and systems engineering but a stint as a regional firefighter prepared him well for working in the Australian outback. "Working as a firefighter makes you keenly aware of safety issues, which is important on the MRO as well," he said.

IMPROVED SUCCESS IN MEGA SCIENCE PROJECTS

What is it that makes the construction of some mega science projects successful while others run over time, over budget and without delivering the performance promised? This was a question posed by (now Doctor) Phil Crosby and supervisor Professor Peter Hall at the start of his PhD research into how to successfully manage a mega science project.

'Phil's research has taken him from Davis Station in Antarctica, to the Large Hadron Collider beneath the French-Swiss border.'

Phil found that it was almost the accepted "norm" for the construction of very large projects, including science projects, to run over time and over cost. Even worse, in the last 100 years we have not improved the track record of delivering big projects. Many studies have looked at what makes projects fail but Phil wanted to find out what good projects had in common, and whether these traits could be used to lift the probability of mega science triumph. With the construction of the Square Kilometre Array (SKA) on the horizon, he set out to find a formula for success.

Phil began by choosing recent and current case study projects that were expensive (costing more than $100m), technologically challenging, had defined science goals and needed infrastructure to be built: projects such as a radio telescope or a particle collider. From each facility he wanted to tease out what it was that had made that project perform well, or not so well. So he visited them. Phil's research has taken him from Davis Station in Antarctica, to the Large Hadron Collider beneath the French-Swiss border and to 14 other notable mega science projects around the world. At each site he spent time with the project managers, team leaders and staff and took countless notes, recordings and photographs.

Phil investigated the less explored aspects of high technology mega projects, drawing new conclusions concerning the importance of defining success, characterising complexity and establishing productive collaborations. He delved into major project procurement systems, resilience building, and improved methods of project review. His work led into project sociologies, such as the non-obvious traits of project managers, and how these may be useful when recruiting mega project leaders, as well as techniques shown to lead to project success.

Phil found that a relatively small number of things had a very large impact on the success of the project. Surprisingly, factors such as standard risk management and system engineering approaches, while necessary, had a small bearing in detail on success, while "softer" factors such as social capability, information control, and expectation management ranked surprisingly high.

In fact, a further meta-investigation of almost 300 published project cases revealed that the three most important drivers of success were:

1. Project management control and execution systems, with robust policies, planning, procedures, document control, audit, etc.
2. Clear project definition, specified requirements, goals, objectives, scope and sound business case.
3. Mature project communication, information systems; and effective public relations management.

This central work informed Phil's wider research, which concluded with a number of key areas where mega project managers should apply focus for improved chances of success.

An early goal of Phil's research was to generate a practical outcome from the work so he also developed a simple, yet comprehensive, checklist that can be used by the managers of future mega science projects such as the SKA. This 60 question audit document is divided into the stages of the project and allows managers to benchmark the effectiveness of project artefacts and control systems at each stage of project execution.

1
Goldstone Deep Space Communications Complex in California. Credit: NASA.
2
Electronic testing equipment ready for work in the engineering lab.

TRANSIENTS

Studying a black hole or a distant galaxy is a matter of pointing a telescope at the right area of the sky. But how do you record an event that happens without warning and is all over in less than a second? This is a challenge faced by ICRAR researchers in their search for ways to detect massive bursts of energy in the Universe, called fast transients.

'The field is so new that scientists do not yet know what they might find.'

Fast transients happen on sub-second time scales and can be very difficult to detect and study. Some, such as pulses from pulsars, happen at regular intervals while others, like supernovas and gamma ray bursts, are one-off events and happen without warning. Even pulsars can generate giant one-off pulses.

Digital systems specialist Dr Nathan Clarke is part of a team of ICRAR researchers taking on the challenge of detecting fast transients. Through the development of digital instrumentation the team will use the ASKAP telescope to search for these elusive events, with a view to pioneering the development of similar instruments for the SKA.

The field is so new that scientists do not yet know what they might find and hope to detect fast transients emitted from previously unknown astronomical objects and physical phenomena. But for Dr Clarke the unknown element is what makes it so interesting. Fast transients can even be used to look at the material in space between the source of the transient and Earth, the interstellar or intergalactic medium.

After months of work, the ICRAR team in collaboration with colleagues from NASA's Jet Propulsion Laboratory came up with a system to detect fast transients suitable for use on the ASKAP telescope. They wanted to test it on a fully operational telescope so installed the instrumentation on a NASA deep space tracking network telescope at Goldstone, California in August 2012. The system was originally designed to allow ASKAP to look for events on a tiny one millisecond time scale but the test version, which runs on only one dish rather than ASKAP's 36 dishes, looks for events down to 0.1 of a millisecond in duration.

The ICRAR system for detecting fast transients was deployed on a NASA deep space tracking telescope in California in August 2012.

ICRAR researchers have developed new insights into how interstellar and intergalactic matter may affect the detection of transient radio signals from space, and how this affects the design of new telescopes such as the SKA.

Achievement 2011–2012

THE ENGINEERING LAB

ICRAR's engineering laboratory is a place where the ideas of our engineers and scientists move from the drawing board to the real world. The unique radio frequency investigation laboratory, at ICRAR's Curtin node, gives researchers the space, equipment and supplies they need to build and test new technologies before they are deployed on the Murchison Radio-astronomy Observatory site in the WA outback.

With over two million dollars worth of cutting-edge equipment, it is far from a typical student laboratory. Researchers have access to equipment similar to that in a commercial communications research laboratory as well as screening facilities to block out radio noise. Astronomers are also invited into the engineering side of things and given space and expertise to help their ideas come together, resulting in cross-disciplinary interactions between staff and students alike.

In the past year the engineering laboratory has been used for:

- Development of new RF circuitry for SKA-low verification systems.
- Verification and upgrade of receivers for the Murchison Widefield Array telescope.
- Development of conical spiral antennas that are the receiving parts of a system to study the Epoch of Reionisation.
- Implementation of smaller test projects, such as adapting radio receivers typically used for TV tuners for use in astronomy instruments.
- Research student projects, including investigations into solar power solutions for front-end electronics and high-sensitivity electromagnetic compatibility measurements.

The laboratory is used to develop customised new products away from the commercial path but ICRAR engineers have a philosophy of using commercially available systems where available, ensuring that high-value engineering development effort is directed to areas where it is most needed.

MWA ENGINEERING COMMISSIONING

The past year has seen the Murchison Widefield Array (MWA) telescope slowly take shape in the West Australian outback. Under the watchful eye of Commissioning Engineers Dave Emrich and Brian Crosse, the area has been transformed from a patch of red dirt with only kangaroos and lizards nearby to the home of one of the most advanced radio telescopes in the world. All 4,096 antennas and 128 beam formers have now been installed on the 128 mesh "tiles" that fan out across the landscape to make up the MWA.

The engineering management process has involved everything from fielding the mechanical and electronic components of the instrument to organising site visits and liaising with suppliers and other partners to make sure things arrive on time and fit where they are supposed to fit. The first part of the infrastructure was built by contractors on the site early in 2012 before ICRAR staff and an army of ICRAR students took over the more difficult parts of the build later in the year.

The MWA was officially launched on November 30, 2012, and has begun to receive its first data, although engineers expect to be installing software and tweaking the telescope until mid 2013.

1
PhD Candidate Aziz Jiwani with his prototype conical spiral antenna.

EPOCH OF REIONISATION INSTRUMENTATION

One of the most challenging engineering projects has been the instrumentation for BIGHORNS, a project led by the ARC Centre of Excellence for All-sky Astrophysics (CAASTRO). This research aims to detect the signal from a period early in the history of the Universe when the first stars and galaxies were forming.

BIGHORNS is ultimately a science-driven experiment but it is not as easy as building a simple system, taking a week's worth of data and being finished. The signal from neutral hydrogen gas during this time, called the Epoch of Reionisation, is extremely faint, so understanding and calibrating the equipment is really the name of the game. The sought-after modulation in the signal spectrum is so tiny that it is essential to understand how each part of the system behaves, so there are no small systematic effects that masquerade as the real signal.

ICRAR researchers working on BIGHORNS have designed and built unusual conical spiral antennas that stand about 2m high and cover a wide range of the frequency spectrum. Next comes the signal chain from the antenna all the way down to data being written to a disk at the other end — ICRAR's industry partner Raytheon, who are experts in radio frequency engineering, designed and built the analogue part of the signal chain while the later part of the signal chain, the spectrometer, is a collaboration between ICRAR and CSIRO.

STUDENT HIGHLIGHTS

Tahereh (Tara) Rashnavadi, PhD Student

THESIS: DEVELOPMENT OF HARDWARE SYSTEMS FOR HIGH TIME RESOLUTION RADIO ASTRONOMY

Tara Rashnavadi came to ICRAR in May 2012 to research the instrumentation required to detect the phenomena known as 'fast transients'. These events, such as pulses from pulsars and on-off gamma ray bursts, happen on sub-second time scales and are very difficult to detect and study.

Tara's initial project involves implementing a digital spectrometer, an instrument that breaks down radio signals into frequency components, and an associated high speed signal analysis system. Spectrometers have been used for a long time in astronomy but this research will develop one optimised to detect fast transients. Tara's project involved programming field-programmable gate arrays (FPGAs) on a circuit card designed to receive analog signal from a telescope, convert it into a digital signal and break the signal up into its spectrum, or the frequency components of the signal. Ultimately, Tara's work is aimed at delivering instrumentation scalable to very large systems, such as the SKA.

The Iranian student has a background in signal processing and always dreamt of working in astronomy but never thought she would be able to. Now she thinks her dream has come true.

Cdr. Chittawan Choeysakul, PhD Student

THESIS: CHARACTERISATION OF A REVERBERATION CHAMBER MODEL FOR ELECTROMAGNETIC EMISSION MEASUREMENTS

Chittawan Choeysakul was inspired to study electrical engineering by one of the worst natural disasters in history, the 2004 Indian Ocean Tsunami that claimed the lives of over 230,000 people.

The PhD student is a Commander in the Royal Thai Navy and completed an undergraduate degree through the naval academy before spending five years working on a ship as a weapons officer and navigator. During his time on the battle ship, Chittawan was given the grim task of collecting bodies in the Andaman Sea, near Phuket and Phi Phi islands, following the devastating tsunami. He became frustrated that it was very difficult to use communication systems during the disaster and realised that if more was known about engineering the problems might have been avoided.

Inspired by his experience, Chittawan went on to study antennas as part of his Masters degree and has received a scholarship from the Royal Thai Navy to do a PhD at ICRAR. His work is in electromagnetic compatibility, a discipline which looks at, amongst other things, whether two or more items of equipment might interfere with or interrupt each other. It is an area of concern to radio astronomers wanting to limit interference from equipment when studying very weak signals from space but it is also of interest to the Royal Thai Navy and is very important with almost all modern equipment, such as defibrillators in hospitals.

In the past, electromagnetic emission measurements for radio astronomy have been done in an anechoic chamber but Chittawan's research has been able to prove that more accurate measurements, and measurements more accessible to industry, can be made in a reverberation chamber. For this work Chittawan was awarded the best student paper award for 2012 by the Electromagnetic Compatibility Society of Australia.

ICRAR PhD Student Cdr. Chittawan Choeysakul awarded Electromagnetic Compatibility Society of Australia's Best Student Paper.

Achievement
2011–2012

INFORMATION & COMMUNICATIONS TECHNOLOGY

1
Inside the Murchison Radio-astronomy Observatory computing facility.
Credit: Paul Nicholls, iVEC.

ICT OVERVIEW

1
iVEC's Fornax supercomputer, located at UWA.: iVEC@UWA.
2
Former Federal Minister for Science Kim Carr and Minister Troy Buswell initiate the construction of the Pawsey High Performance Computing Centre. Credit: iVEC.
3
A rear view of Epic, a HP commodity linux cluster housed in a Performance Optimised Datacentre (POD). Credit: iVEC.
4
Paul Bourke, Associate Director of iVEC@UWA amongst the racks of the Fornax supercomputer. Credit: iVEC@UWA.

Radio telescopes, the engineers that build them and the scientists that extract science from the data they gather, are becoming increasingly reliant on the advances being made in the ICT domain. As the SKA comes online between 2020 and 2025 the computational elements of the telescope will need to process up to an exabyte, or one billion gigabytes, of data every single day, requiring supercomputers that are faster, larger and more energy efficient than anything available today.

Helping to overcome the data challenge is ICRAR's ICT and high performance computing team. Their job is to design and implement the systems and architecture required to gather, share and analyse the SKA precursor radio telescopes - the Australian SKA Pathfinder (ASKAP) and the Murchison Widefield Array (MWA). This work is helping the ICRAR team to develop the architecture that will enable the SKA to achieve exascale data processing.

International Collaborations

ICRAR is working closely with institutions and colleagues around the world in fields involving science, engineering and ICT. In the ICT domain the Centre collaborates with facilities and industry leaders to help address common data intensive challenges for those designing and constructing the next generation of both radio and optical telescopes. ICRAR's ICT team collaborates internationally with industry leaders and institutions such as Intel, ThoughtWorks, CISCO, Data Direct Networks, the Large Synoptic Survey Telescope, the PanSTARRS project, University of California Davis, the Canadian Astronomy Data Centre and, more locally, with Systemic, iVEC and Murdoch University in Perth.

These collaborations cover a wide range of themes from storage over networking and global data transfer to processing, workflow systems and citizen science. While our ICT team is relatively small, these collaborations allow us to cover a broad variety of topics in order to architect the SKA data system in a holistic way. The exascale data flow of the SKA will require optimised, data-centric design throughout the system to allow scientists to analyse and access the vast quantities of information.

The SKA Science Data Processor Consortium

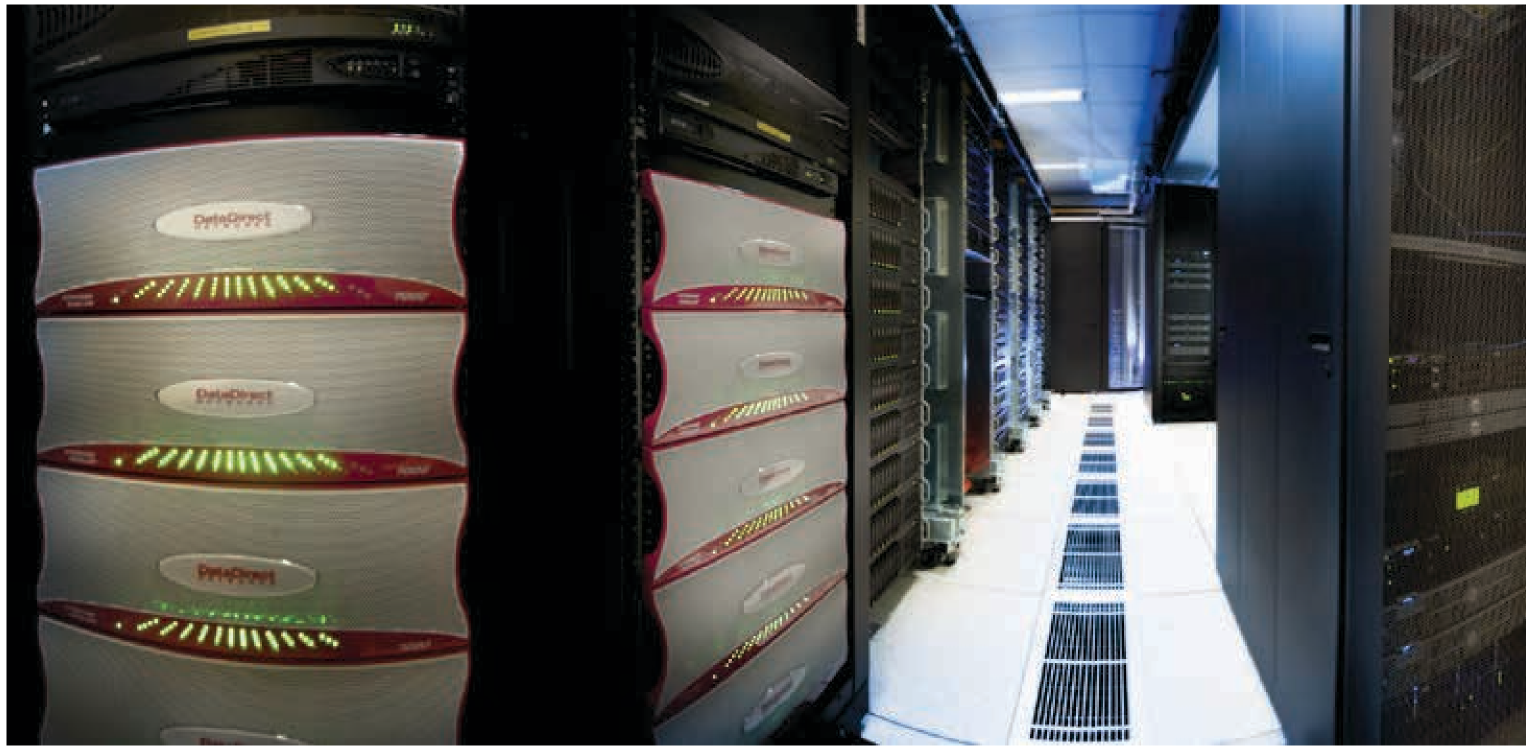
ICRAR's ICT program's main focus is to play a major role in the design and implementation of the SKA software and computing system. More specifically we are concentrating on the 'SKA data layer' which controls data transfer and storage (both short and long term) throughout the telescope. In this respect our ICT team has been very active in forming and organising an international consortium to respond to the official request for proposals expected to be issued by the Office of the SKA Organisation (OSKAO) sometime in early 2013. The SDP pre-consortium is led by the University of Cambridge and ICRAR and consists of members from 15 different organisations located around the world. Setting up such a globally distributed team to work together towards common goals and objectives in an efficient way is a challenge in its own right. The enthusiasm and dedication of all parties involved helps, but proper project management and appropriate and efficient tools, guidelines and procedures are at least as important. To help meet this challenge we have worked together with ThoughtWorks, one of the leading consulting companies, to define and propose a potential software development environment for the SKA.

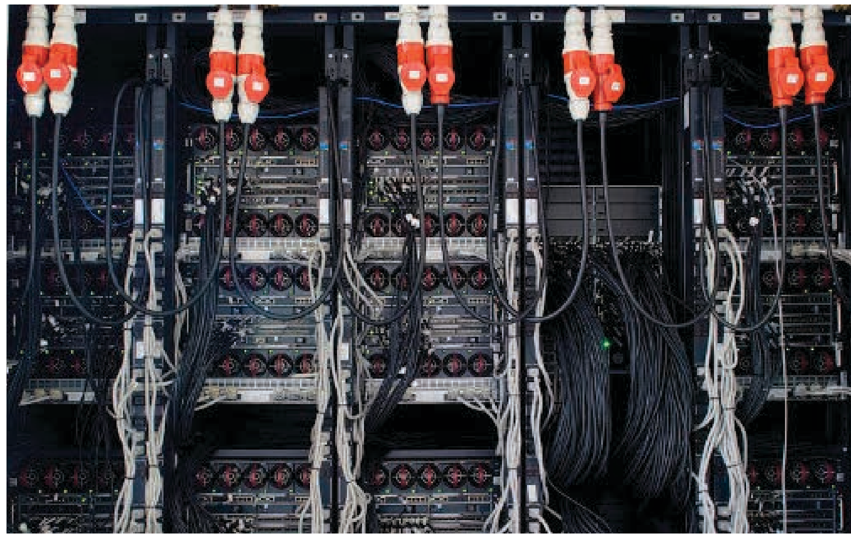
iVEC and the Pawsey Centre

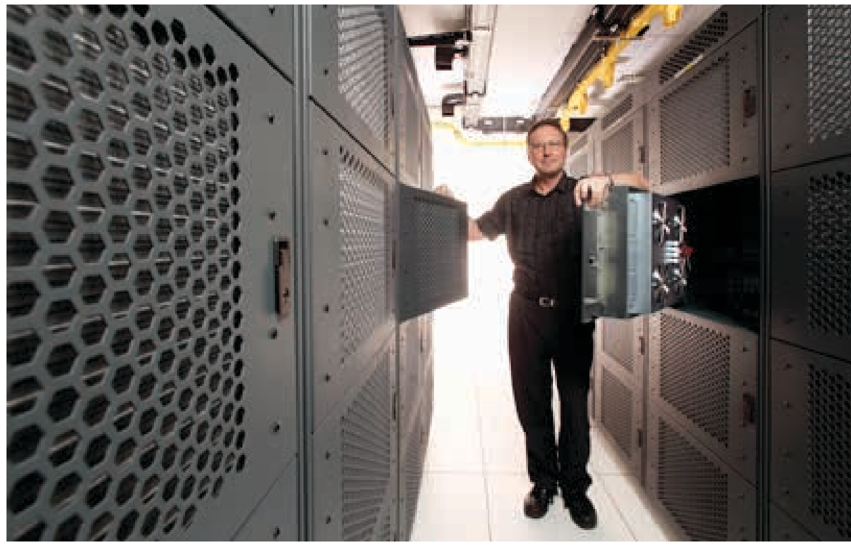
As part of its 2009 Super Science Initiative, the Australian Government allocated $80 million to iVEC to establish a petascale supercomputing facility to be known as the Pawsey High Performance Computing Centre, named after pioneering Australian radio astronomer Dr Joe Pawsey. When completed in 2013 The Pawsey Centre will bolster Australian eResearch infrastructure through the provision of a petascale supercomputing facility that will support the computational and data processing capabilities required to fully implement the ASKAP and MWA radio telescopes. ICRAR's ICT team had been active in collecting the requirements for the Pawsey Centre and in the technical evaluation of the responses to the request for proposals from the various vendors. In particular the requirements for data intensive science had been pushed forward during the procurement phase of the Centre.

Down to Earth benefits

Through wireless communications, medical imaging, atomic clocks, GPS navigation, spacecraft navigation systems and innumerable spinoff technologies, the world is already reaping the rewards of astronomical endeavour. Overcoming the challenge of processing and distributing data for the SKA, its precursors and other astronomical facilities will no doubt continue this trend and add to the growing volume of down to earth benefits for billions of people around the world. This is clearly reflected in the interest the SKA has already raised with companies locally and globally.







MWA DATA ARCHIVE

Every second the Murchison Widefield Array (MWA) radio telescope will generate 450 MB of processed data, a phenomenal amount of information that could contain the next great discovery for science. ICRAR is responsible for building the entire end to end data archive system for the MWA, from the data capture at the telescope site in outback Western Australia to its eventual storage in a tape archive located in Perth. As with the rest of the project, the challenge has been to deliver the system on a very limited budget.

'ICRAR has a close connection with the Pawsey Centre, which in itself is a multi-million dollar collaborative project, and the MWA has a hefty 15 petabyte allocation at the facility.'

ICRAR's ICT team, led by Research Winthrop Professor Andreas Wicenec, have based the telescope's archive infrastructure on a system called NGAS created by the European Southern Observatory to capture the data from the Very Large Telescope (VLT) in Chile. This system has also been used for other projects like the Atacama Millimetre and Submilliemtre Array (ALMA) and the US National Radio Astronomy Observatory (NRAO) Very Long Baseline Interferometry data archive. The maximum data flow ever captured by the software for the ALMA was about 64MB per second in peaks, well short of the 450MB per second sustained needed for the MWA.

The raw data rate generated by the antennas is phenomenal. But that information is quickly processed by the MWA's backend systems and never stored in its raw state. By the time the data is sent to Perth it has already been through two stages of processing and is small enough that it can be captured and transferred through fibre optic cables to Geraldton and then down to Perth.

The data initially lands on a computer at ICRAR's UWA node before a subscription mechanism pushes the data to iVEC's Pawsey Centre and the Massachusetts Institute of Technology in the United States. MWA data will ultimately be stored in a tape archive housed at the Pawsey Centre, a supercomputing facility in the Perth suburb of Bentley. ICRAR has a close connection with the Pawsey Centre, which in itself is a multi-million dollar collaborative project, and the MWA has a hefty 15 petabyte allocation at the facility.

In principle, scientists could pull data directly from the Pawsey tape archive but the next part of the project will be to build a scientific data portal for researchers to access the observations in a much more convenient way. The data stored in the Pawsey Centre is still in a fairly raw form so before it can be used by astronomers it will need to undergo further processing stages to transform the data from time -sorted numbers to image cubes. These image cubes are essentially a stack of monochrome images across many spectral channels. They are still extremely large but the image cubes are the primary step at which scientific evaluation can begin.

The MWA has 128 "tiles" and was commissioned in 32 tile blocks, with the MWA team building up and fully equipping each block in turn. The full MWA data archive system is already operational during the commissioning phase, with the data traversing the 800km from the MRO to Perth.

It is hoped the challenge of building the full MWA data archive will put ICRAR in a strong position to contribute to the information technology requirements of the SKA. The volume of data expected to come from the MWA is one tenth of that predicted for the first phase of SKA-low and one percent of the full low frequency array. While one percent might not seem like a lot, the jump from existing technology to that required by the MWA is enormous, particularly when the low cost requirement is taken into consideration.

A link has been established between the Murchison Radio-astronomy Observatory in outback Western Australia and Perth, 800km away. Data is sent from the site to a machine in ICRAR and then to a tape archive at the Pawsey Centre, Perth, and Massachusetts Institute of Technology in the United States.

Achievement 2011–2012

RESEARCHER PROFILE
A/PROF. CHEN WU

'We're actually tackling the same problems being tackled by the smartest engineers in the world.'

Chen Wu
Research Associate Professor

Associate Professor Chen Wu's work on data transfer, storage and retrieval for the Murchison Widefield Array (MWA) telescope puts him at the top of his profession globally. "The problem we're currently dealing with is also being dealt with by engineers working at Google, Facebook and all these IT companies," he said. "If they're saying they're hiring the smartest software engineers then we're actually tackling the same problems being tackled by the smartest engineers in the world. So it's very interesting and exciting work we're doing here."

Associate Professor Wu's research on the MWA data archive involves finding ways to capture information at a rate of 400MB per second at the Murchison Radio-astronomy Observatory site in the West Australian outback and transfer it to Perth through fibre-optic networks. From there the data is sent to MIT in the United States and archived at iVEC (Perth), both in a permanent storage facility and a temporary online storage. The stored data must also be organised in a way that is easy for astronomers to search, retrieve and reprocess.

Associate Professor Wu grew up in China and worked as a software engineer and a researcher at the Chinese Academy of Sciences before moving to Perth to do a PhD in data retrieval and storage and postdoctoral research in pattern recognition. He said he enjoyed the balance at ICRAR between academic research and contributing to real projects. "It's no longer just writing a paper, it's about getting real, exciting things done that can serve the scientific community," Associate Professor Wu said. "It's a kind of hybrid between academia and industry."

THESKYNET

One of the biggest problems in radio astronomy is finding the computing power needed to process the massive amounts of data collected by telescopes. Enter theSkyNet — a citizen science project that aims to raise the public profile of science and radio astronomy while simultaneously creating a research grade data processing resource for scientists. TheSkyNet allows members of the public to donate their spare computing power to process radio astronomy data, with the software running quietly in the background of users' personal machines.

Since launching in September 2011, this initiative has already enjoyed significant success, experiencing large uptake by audiences around the world, with around 2,500 machines online and contributing at any given time, day or night. This adds up to a distributed network capable of performing more than one million processing tasks per day, placing theSkyNet on par with a supercomputer with 24 TFlops of processing power.

In the first year theSkyNet community made it possible for ICRAR researchers to complete over 1.6 billion processing jobs, equating to approximately 11 million CPU hours with an average job time of 30 seconds. This equates to more than a year of dedicated CPU time for a 1,000 node computer cluster.

To date this resource has been used to search for galaxies in data gathered by the Parkes radio telescope in New South Wales, with much of this work being done to help test "source finding" algorithms that will automatically detect sources in radio wavelength observations. This will be extremely important in the years to come when telescopes like the Australian SKA Pathfinder (ASKAP) become operational.

Recently ICRAR and Johns Hopkins University (JHU) in the US signed a Memorandum of Understanding for theSkyNet to process observations of distant galaxies observed by Pan-STARRS1, an optical telescope located in Hawaii. This large volume of data would take computers at JHU approximately 1,000 years to process, whereas it's believed this can be done in two years with theSkyNet.

2013 promises to be a big year for theSkyNet with the addition of a BOINC pathway, the same platform developed for SETI@home, and the development of theSkyNet interface to allow users to see real images of the galaxies their computer has processed observational data for.

'In the first year theSkyNet community made it possible for ICRAR researchers to complete over 1.6 billion processing jobs.'

theSkyNet

theSkyNet launched in September 2011, with almost 3,000 users signing up in the first 24 hours.

Achievement 2011–2012

1
A large number of 'green' cpu cores packed on to a single integrated circuit. One possible solution to exascale supercomputing.

THOUGHTWORKS

Imagine a company that allowed its staff to donate their work time to a worthwhile cause of their choice. International software consulting business ThoughtWorks has a program that provides free manpower to organisations like UNICEF for tasks such as hospital management software to be used in African hospitals. Employees participate in the program while they are between projects, time referred to within the company as being "on the beach", and can choose what they contribute time to from a range of social, humanitarian and science causes.

'Employees participate in the program while they are between projects, time referred to within the company as being "on the beach", and can choose what they contribute time to from a range of social, science and humanitarian causes.'

ICRAR was approached by ThoughtWorks following an Australian Computer Society talk by Research Associate Professor Kevin Vinsen and asked if "on the beach" employees could contribute to the Centre's work. As an internationally collaborative Centre, ICRAR seized the opportunity and came up with several interesting short term projects that ThoughtWorks employees could choose to contribute their time and expertise towards.

Because of the nature of the collaboration, some of these projects are at the final stage of release while others are yet to be taken up. ThoughtWorks consultants can be available to work on these projects for anything between a few days and a month but it is usually only a couple of weeks. For this reason it is important that the projects offered are interesting enough to entice the ThoughtWorks staff but not absolutely critical to the Centre.

Some of the ICRAR projects on the beach ThoughtWorks employees have contributed to so far include:

- A BOINC module for citizen science project theSkyNet.
- A module for planetarium software Stellarium that will allow researchers to do survey monitoring for the Murchison Widefield Array (MWA), Australian SKA Pathfinder (ASKAP) and SKA telescopes.
- A parameter database for the SKA, based on a similar tool developed for one of the cornerstone satellite missions of the European Space Agency.

ICRAR and ThoughtWorks have also prepared a conference paper that describes ways the agile software development paradigm, one of the main concepts ThoughtWorks is using, could enable more efficient implementation of the SKA software, given the highly distributed SKA development environment.

INTEL

ICRAR's cutting edge ICT research is attracting the interest of some of the most innovative companies in the world, with global computing giant Intel one of the latest to seek out a collaboration with the Centre.

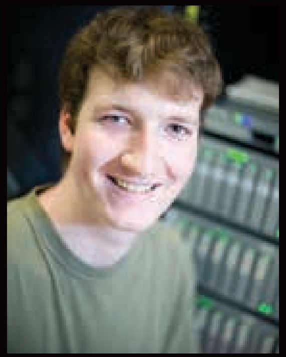
In 2011, ICRAR was invited by Intel to become one of a few selected partners in the world for early adaption of a new "Many Integrated Core" processing technology later announced as Xeon Phi. This new technology provides a roadmap to Exascale computing, which is required to make the SKA possible. Xeon Phi is essentially a microchip of densely packed processors capable of executing over a trillion calculations per second.

Research Fellow Richard Dodson and Research Associate Professor Slava Kitaeff have been testing Xeon Phi on astronomy problems such as N-body simulations for modelling physical processes in star forming regions, baseband signal correlation of data from radio interferometers and new compression and data interrogation techniques for enormously large spectral-imaging data from new radio telescopes.

In June 2012, Dr Dodson joined Intel for the launch of Xeon Phi at the International Supercomputing Conference in Germany while Dr Kitaeff, together with Intel, was invited to present at the ACM International Symposium on High-Performance Parallel and Distributed Computing in Holland.

The successful collaboration continued with Intel's grant of two new Xeon Phi systems to ICRAR. The Pawsey supercomputer may utilise Xeon Phi technology so these test beds will allow early development and tests to be performed.

STUDENT HIGHLIGHTS



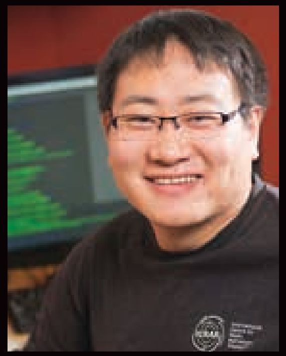
Stefan Westerlund, PhD Student

THESIS: A PARALLEL SOURCE FINDER FOR SEARCHING RADIO ASTRONOMY IMAGES USING HIGH PERFORMANCE COMPUTING

Stefan Westerlund's PhD is allowing him to access some of the best supercomputing facilities in Australia — the Epic supercomputer at Murdoch University, Fornax at UWA and soon the $80 million Pawsey Centre.

Stefan's research is in source finding, a process of looking for objects such as galaxies within astronomical data. He is working on a source finder for the WALLABY and DINGO surveys of the Australian SKA Pathfinder (ASKAP) telescope. WALLABY alone is expected to be able to detect over half a million galaxies. Finding them in the image data cubes produced by the ASKAP data reduction system is a delicate and complicated task, so a source finder like Stefan's will be critical to the survey's success. New telescopes such as ASKAP and the SKA will produce phenomenal amounts of data and so the main part of Stefan's work is in trying to search the data quickly and efficiently in order to keep up with the rate at which it comes from the telescope.

Stefan completed an undergraduate degree in computer science and electrical and electronic engineering at UWA and did his final year engineering project with iVEC. He made the move to astronomy when his supervisor suggested it would be fascinating to work on data processing facilities required for new telescopes such as the Murchison Widefield Array (MWA), ASKAP and the SKA.



Ruonan (Jason) Wang, Masters Student

THESIS: AN MPI-OPENCL BASED RADIO ASTRONOMY SOFTWARE CORRELATOR ON HETEROGENEOUS CLUSTERS WITH ASYNCHRONOUS COMPUTING TOPOLOGIES

For his Masters thesis, Jason Wang looked at signal correlation, one of the first steps in data processing for a radio telescope array. Correlation is likely to be a challenge for next generation telescopes such as the SKA simply because of the volume of data they will collect. As part of his work, Jason developed a software correlator optimised to run on graphic processing units (GPUs), just like the ones driving the displays of your laptop or desktop computer. In order to verify the efficiency, throughput and scalability he ran his code on the Fornax supercomputer at UWA.

Jason finished his Masters in June 2012 but has stayed on with ICRAR to do his PhD in data management. Jason realised during his Masters, while evaluating the scalability requirements, that one of the biggest problems for next generation radio telescopes is not the actual processing but rather the time taken to feed the data into the system ready for processing. This is one of the challenges he hopes to tackle in his PhD along with improving data retrieval systems.

Derek Gerstmann, PhD Student

THESIS: ULTRA-SCALE VISUALISATION WITH ADAPTIVE RESOURCE MANAGEMENT FOR DATA INTENSIVE SCIENTIFIC RESEARCH

Derek Gerstmann is helping ICRAR's scientists to uncover the structure of the Universe by developing tools to visualise vast quantities of astronomical data. His research focuses on interactive tools for large-scale data analysis and visualisation, to provide scientists with a better understanding of their data and their research.

Until the next generation of telescopes such as the Australian SKA Pathfinder (ASKAP) and the SKA come online, most of Derek's visualisation work has been geared towards the astrophysics simulations produced by other ICRAR researchers. His work offers the ability to present data in such a way that new insights and features are uncovered, with the ultimate goal of presenting new information that is difficult or challenging to recover using traditional methods.

Derek grew up in the United States and received his undergraduate degree in software engineering and computer science at the University of Washington. He did a Masters in computer animation at the National Centre for Computer Animation at Bournemouth University and worked in industry for several years before deciding to go back to university to undertake a PhD.

This YearBook contains several images from Derek's work, but these static images only offer a glimpse of the actual, fully interactive data visualisation tool he is working on. To see a full animation check out www.vimeo.com/icrar/askapsurveys

MRO/ THE MURCHISON WIDEFIELD ARRAY

1
The full Moon lights the ancient Murchison landscape to reveal a 'tile' of the Murchison Widefield Array.
Credit: Pete Wheeler, ICRAR.

1
The core of the Murchison Widefield Array.
2
A local resident of the MRO— a Bungarra Lizard.

MURCHISON WIDEFIELD ARRAY

'The MWA shows that it is possible to build a powerful telescope with an enormous collecting area without a hefty price tag.'

The past year has seen the Murchison Widefield Array (MWA) telescope take shape in the middle of the West Australian outback. In the ancient and awe-inspiring landscape of the Murchison, amongst some of the oldest rock formations in the world, the mesh "tiles" and spider-like antennas of the MWA work silently together as they watch the endless sky above.

Led by Deputy Director Steven Tingay, the MWA is one of only three precursors to the SKA, along with MeerKAT in South Africa and the Australian SKA Pathfinder (ASKAP). This ground breaking low-frequency telescope will play a major role in informing the design of the low frequency part of the SKA and will be the first of the three precursors to be completed.

The telescope collects radio waves with frequencies between 80 and 300 MHz, a part of the radio spectrum which is also inhabited by the FM radio band, one of the reasons the MWA is located in the extremely radio quiet MRO. But this choice of site, seemingly in the middle of nowhere, comes at the cost of having to develop infrastructure in one of the oldest and most remote locations on the planet. The MWA has been able to make use of the infrastructure, power and Indigenous Land Use Agreement established for the site by CSIRO for the Australian SKA Pathfinder (ASKAP) telescope.

The MWA is a collaboration between 13 research institutions in four countries (Australia, India, New Zealand and the United States) and is led by Curtin University. The project has also engaged with industry, developing partnerships with both global companies and local small to medium enterprises.

The MWA shows that it is possible to build a powerful telescope with an enormous collecting area without a hefty price tag. The telescope on the ground was built with relatively cheap materials; aluminium dipoles, builder's mesh and cable similar to that used to connect home televisions. Rather than always hiring contractors, the telescope was built with the help of interested volunteers from within ICRAR, including a "student army" who screwed together dipoles, attached them to the tiles and connected the antennas.

As a precursor, the MWA has an obligation to pass the lessons of building the telescope on to the international SKA project. The project is a stepping stone to SKA Phase 1 and ICRAR will be looking for opportunities during the SKA pre-construction phase to utilise the experience of building the MWA.

ICRAR has been able to build up an experienced group of staff who are well equipped to work at the MRO, placing them in a good position to contribute to SKA-low. In a very practical sense, the infrastructure built for the MWA is over specified for what is needed now, so there is excess infrastructure that can host SKA Phase 1 prototypes during pre-construction.

From a science perspective, detecting the signal from the Epoch of Reionisation, a time early in the history of the Universe when the first stars and galaxies were forming, is one of the big goals for SKA Phase 1 and is also part of the science mission of the MWA. It is hoped the MWA will make the first observations from this time, if not detecting the Epoch of Reionisation directly then putting stringent limits on detection and informing the design of experiments for the SKA.

Design

The MWA is a new generation "aperture array" telescope, meaning its innovative design has no moving parts, instead it relies on computing power to point at astronomical objects and process the data it collects from the sky. The telescope has 4,096 antennas, split up into 128 groups of 32 called "tiles" that are spread as far as 3km apart. It is designed to have an excellent field of view on the sky (about 500 full moons) and to be very adaptable, being almost exclusively electronically controlled.

'ICRAR will be looking for opportunities during the SKA pre-construction phase to utilise the experience of building the MWA.'

Science

Given the field of view and adaptability of the MWA, the research possibilities are broad and far reaching.

Epoch of Reionisation

We know what the Universe looked like soon after the Big Bang, and we know what it looks like now, but how did it get from one to the other?

By looking at the hydrogen gas that filled the Universe at the time the first light began to shine, it's possible to tell what the Universe looked like at an in-between period when the first stars, galaxies and quasars were forming. The MWA has been designed to take a very wide view of the sky over many wavelengths to detect the signals from this gas and examine its properties.

Space Weather

Most space weather observations are either of the Sun itself or the regions of space close to Earth. However, the MWA will be capable of monitoring the entire region between the Sun and Earth, studying solar bursts and tracking them through space on their way to us.

The Transient Universe

The MWA's ability to look at large parts of the sky for long periods enables it to detect rare and faint 'flashes' of radio waves that last from only seconds up to days in length. Examples include pulsars and spinning disks of gas around black holes.

Galactic/Extragalactic

Otherwise known as 'everything else!'

The MWA's wide field of view on the sky also makes it an excellent telescope to survey the sky at low frequencies, observing distant radio galaxies, the Milky Way and Large and the Small Magellanic Clouds from its southern hemisphere vantage point.

Location

The MWA is located at the remote Murchison Radio-astronomy Observatory (MRO) in Western Australia's Mid West, approximately 300km north east of the coastal city of Geraldton and within the Shire of Murchison. This outback region is roughly the size of the Netherlands with a resident population of around 140 people and a population density of around one person for every 350sqkm.

Maintaining Radio Silence

The MRO and the surrounding landscape are protected through federal legislation from any activities that might interfere with the operation of radio telescopes within 150km of the core site. The establishment of this Radio Quiet Zone (RQZ) combined with a very small and sparse local population means the MRO is the perfect place for constructing and operating the most sensitive radio telescopes the world has ever seen. In the future the MRO will host SKA-low, the low frequency array of the SKA. Currently the site hosts CSIRO's Australian SKA Pathfinder (ASKAP) and the MWA radio telescopes.

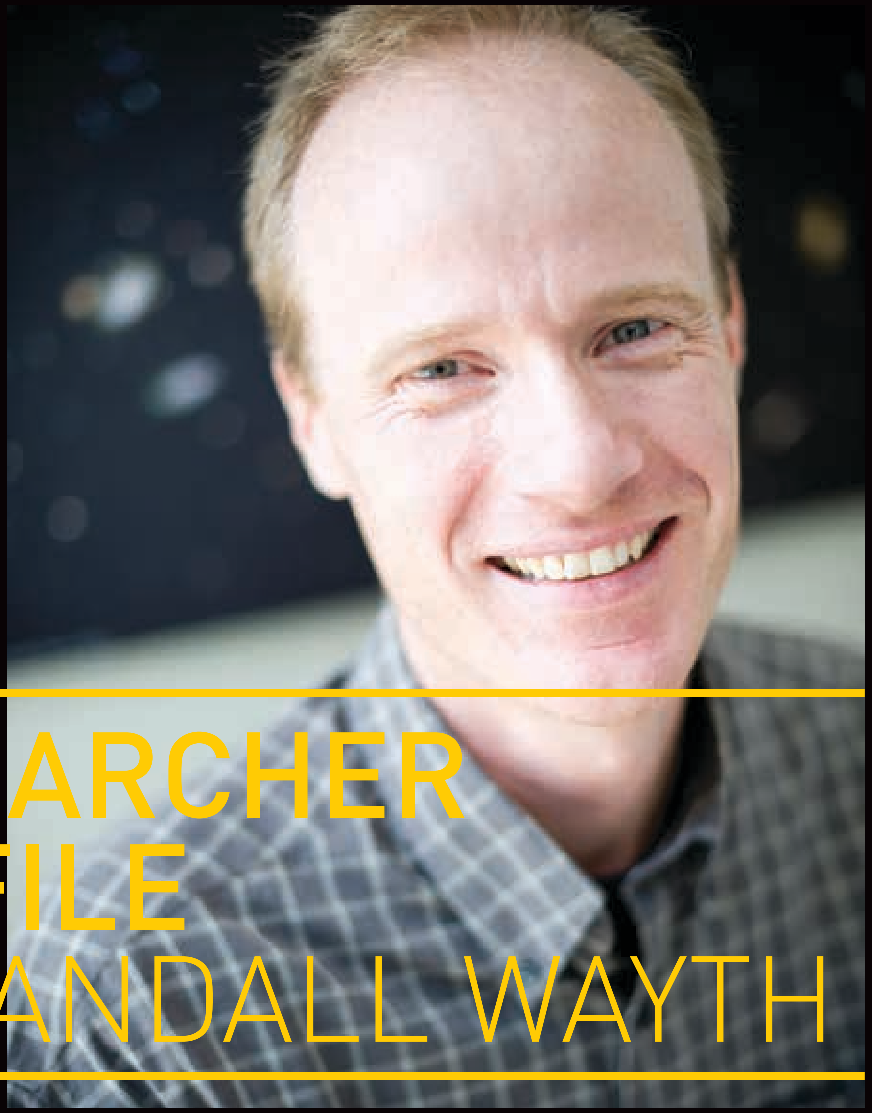
Electromagnetic Compatibility

In building and maintaining a radio astronomy observatory one of the priorities is to conserve the radio quiet environment the observatory is there to take advantage of. Computers, cooling systems, vehicles, power sources and electronic devices all generate radio noise and would easily drown out the faint signals the MRO radio telescopes are attempting to observe. For this reason ICRAR has in-house expertise in electromagnetic compatibility to ensure equipment sent to the site does not interfere with the radio-quiet environment.

1
'Student Army' member Kim Steele clips a dipole onto a mesh tile.
2
The extremely radio quiet environment of the MRO is protected.

The Murchison Widefield Array telescope was built in the West Australian outback and launched on November 30, 2012.

Achievement
2011–2012



RESEARCHER PROFILE DR RANDALL WAYTH

'I'd rather do something that was a bit more noble and contribute to the sum total of human knowledge.'

Dr Randall Wayth
Research Fellow and
MWA Commissioning Scientist

Dr Randall Wayth is working on two of ICRAR's most exciting projects, the Murchison Widefield Array (MWA) telescope and an experiment to find out more about the beginnings of the Universe. As a Commissioning Scientist for the MWA, Dr Wayth is leading a program that aims to survey the entire sky at low frequencies with the innovative telescope.

"It will be pretty much the best thing there is at these frequencies in the southern hemisphere," he said. "There will be a flood of science that follows from that survey. Surveys tend to be quite well cited and well used data products just because people think to use them for something that you yourself wouldn't have thought of."

In addition to his efforts with the MWA, Dr Wayth is working on a separate project in the Murchison called BIGHORNS. This experiment will probe the Epoch of Reionisation, a period early in the history of the Universe when the first stars and galaxies were beginning to form.

Dr Wayth completed an undergraduate in electrical engineering and computer science and worked in industry as a software consultant for five years before turning to astronomy. "I realised that I probably didn't want to work in industry for the rest of my life, that I'd rather do something that was a bit more noble and contribute to the sum total of human knowledge," he said. He had always been interested in astronomy so undertook a PhD in astrophysics at the University of Melbourne and then a postdoctoral position at the Harvard-Smithsonian Center for Astrophysics before returning to Australia to join ICRAR.

Dr Wayth said he enjoyed the way that radio astronomy still gave him the chance to use everything he learnt in his undergraduate electrical engineering degree. He said with so many projects going on at once, ICRAR is an interesting and dynamic place to be. "The people here are fantastic, it's a very dynamic workplace," Dr Wayth said. "We have lots of projects going on so it's a good place where you can get involved in lots of things."

IMAGING THE GALACTIC PLANE

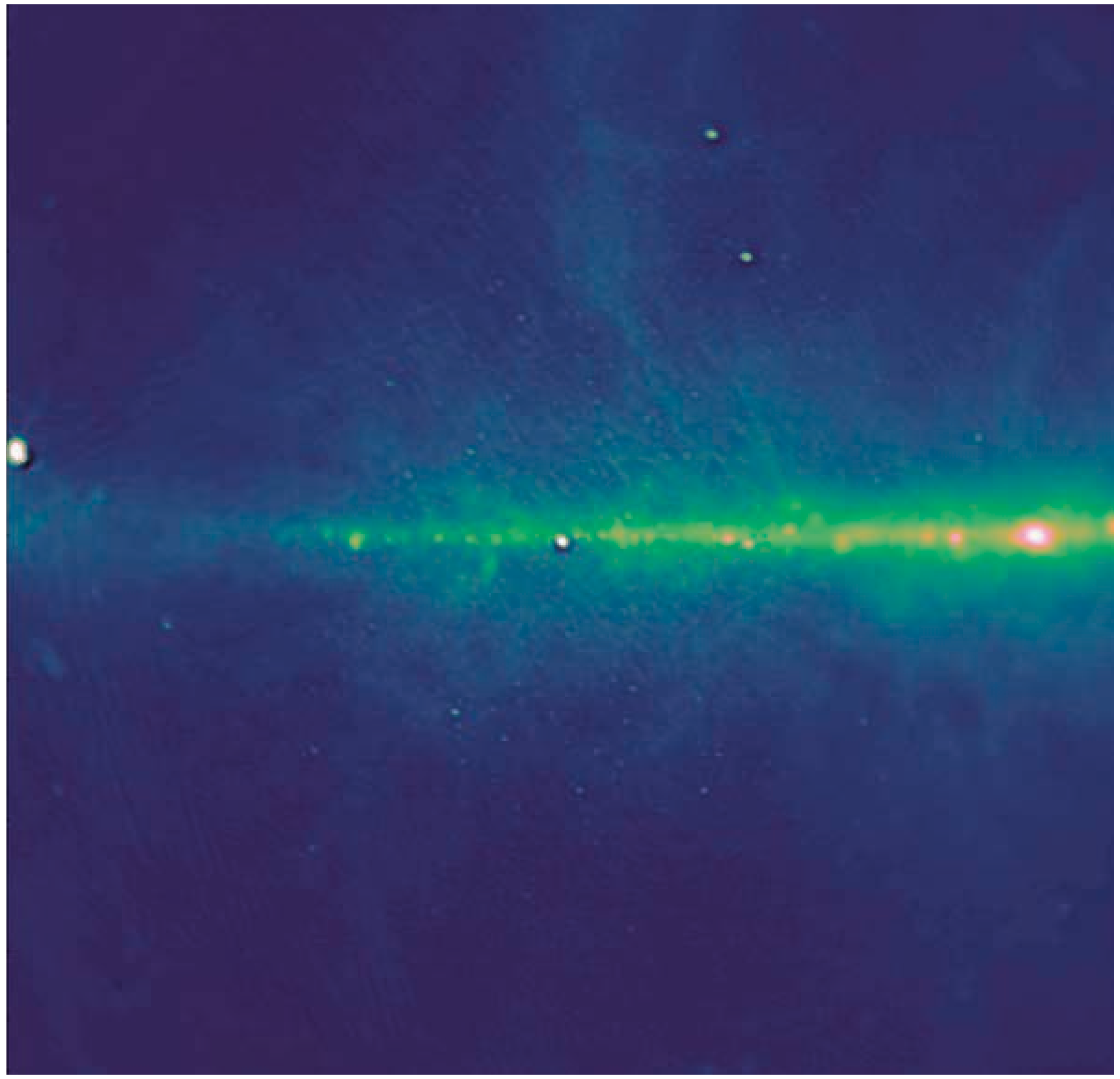
1
Part of the Milky Way as seen by a prototype of the MWA. Credit: Dr Natasha Hurley-Walker, ICRAR.
2
Dr Natasha Hurley-Walker

Find a place far from city lights to view the night sky and you can't help but be overawed by the view of our own galaxy. For Super Science Fellow Natasha Hurley-Walker, this is her laboratory, as she spends her time observing the stars, gas, dust and other material that make up the galactic plane.

Dr Hurley-Walker is involved in the commissioning of the Murchison Widefield Array (MWA) radio telescope and was one of the first people to get her hands on the data from the telescope in 2012. She is piloting a software pipeline that takes the raw information from the 80 to 300 MHz telescope and transforms it into images of the sky.

Until now, all of the images of the Galactic plane have either covered a large section of the sky in broad, low-resolution imaging or very small areas of the sky in good detail but never both. The MWA, with its huge field of view, good resolution and large frequency coverage, will be the first telescope to capture the whole galactic plane in detail at once.

Dr Hurley-Walker has collected preliminary images of the Galactic plane from the MWA prototype and already it is possible to see features that were previously invisible, such as degree-sized filaments and fingers of structure that can tell us about turbulence in the dust and gas around stars. When the telescope is completed in 2013 it is expected to reveal even more information about the galaxy we live in.



THE INDIGENOUS CONNECTION

Western Australia's Indigenous people have always known the night sky was special, giving names to stars, constellations and the Milky Way tens of thousands of years before Galileo ever pointed a telescope towards the heavens. So it seems fitting that part of the SKA, arguably the most advanced scientific experiment ever, will be built on land belonging to the ancestors of these first Aboriginal astronomers.

ICRAR Aboriginal Liaison Officer Robin Boddington, a Wajarri community leader, has been seconded to CSIRO to work with the Indigenous community at the Murchison Radio-astronomy Observatory (MRO). Through Ms Boddington's work, the Murchison Widefield Array (MWA) telescope has been given the Aboriginal name gulgamarnu (gurl-ga-mar-nu), meaning "ear thing" because the telescope is listening to the sky. Each of the 36 ASKAP dishes also have Aboriginal names and Wajarri dancers were present for the launch of ASKAP in October.

Ms Boddington gives visitors to the site a 15 to 30 minute heritage induction on how to respect the land by remaining on tracks, not picking up rocks and staying off hills. Many people working at the site, particularly international visitors, have never spoken to an Aboriginal person before and the induction teaches them about Wajarri culture and language.

Other projects overseen by Ms Boddington as part of the Boolardy Indigenous Land Use Agreement between the Wajarri Yamatji people and CSIRO include:

- The development of an educational resource package in Wajarri culture and history.
- An Indigenous cadetship program.
- A mentor program at the Pia Wadjarri community school that will link students with CSIRO scientists.

1
Aboriginal Liaison Officer Robin Boddington attending an event at the MRO.
Credit: Dragonfly Media.
2
'Student Army' member Sammy McSweeney connects cables to a beamformer.

MWA STUDENT ARMY

A group of ICRAR undergraduate students were given the opportunity of a lifetime when they helped to build the Murchison Widefield Array (MWA) telescope during their winter university break. In July 2012, seven undergraduate students, two ICRAR engineers and Outreach and Education Officer Kirsten Gottschalk made the trip to the Murchison to lend their skills to the construction of the telescope.

The students constructed the spider-like dipoles, clipped them to the mesh "tiles" that make up the telescope, cabled the dipoles to the tiles and installed the beam formers. But it was not all hard work — the students left a few surprises for the commissioning scientists and anyone doing maintenance on the telescope such as dipoles bearing the students' initials, drawings and even a few Lord of the Rings and Star Wars references.

In all, the students spent two weeks in the Murchison, staying at Wooleen Homestead. All were studying astronomy or engineering at Curtin University and most had done a summer internship with ICRAR. As well as gaining experience they will never forget, the students are also likely to be in a position to do a PhD or further research on the MWA and it is hoped helping to build the telescope will give these students and future researchers an intimate understanding of the instrument.

The students' commitment and attention to detail could not be faulted. After having to leave just shy of finishing the work they had planned because of a wet final day, two of the students returned to the Murchison in August with Ms Gottschalk to complete the build.

Student Army Role Call

Brian Crosse
Dave Emrich
Kirsten Gottschalk
Luke Horsley
Sue Khoo
Sammy McSweeney
Jarrod Ramsdale
Teresa Slaven-Blair
Kim Steele
Malcolm Whinfield

OUTREACH

1
A member of the public observes the Moon at the annual Astrofest.

1
One of ICRAR's two demonstration Tiny Radio Telescopes (TRTs).
2
Nobel Laureate Professor Brian Schmidt talks to students at Christ Church Grammar.
3
The ICRAR Outreach team with Apollo II astronaut Dr Buzz Aldrin.

OUTREACH

Connecting with the broader community, promoting uptake and participation in science and communicating our research is an integral part of ICRAR's work. Our team of professional science communicators, with the help of our researchers and postgraduate students, deliver a plethora of outreach and education activities throughout the year, across the country and beyond.

Whether it's the person on the street, the teacher in the classroom or the student about to head off to university, our public lectures, community observing events, school programs, and extensive online presence ensure we are reaching audiences across the spectrum.

In the three years since launch, more than 35,000 people have interacted directly with ICRAR outreach programs, with tens of thousands more engaging through the distribution of educational resources and our strong online presence.

ICRAR has achieved this level of outreach success by developing robust collaborative relationships with others, consistently delivering high quality outcomes through training, as well as supporting and involving our researchers in the programs we provide.

For the 2011-12 period our outreach highlights include:

- A series of events involving Nobel Laureate Professor Brian Schmidt.
- A visit by Apollo 11 astronaut Dr Buzz Aldrin.
- A collaborative tour of schools and communities in the Pilbara region.
- The launch of theSkyNet distributed computing initiative (for which we were nominated as a finalist for a WA Science Award).

Media engagement and events surrounding the SKA site decision.

In the media domain ICRAR performs exceptionally well. Communicating our research in an effective and engaging way through the national and international distribution of media releases and online articles, combined with a strong understanding of the journalistic process, has led to over a thousand articles in print and online to date, with a potential readership of well over 2 million.

By engaging audiences through astronomy we pave the way for the nation's future, and sow the seed for the next generation of scientists and engineers essential for our growth in science and technology.

'In the three years since launch, more than 35,000 people have interacted directly with ICRAR outreach programs.'

ASTROFEST

1
Telescopes ready for the public at Astrofest 2012.
2
ICRAR PhD candidate Giovanna Zanardo explains her work at Astrofest 2012.
3
Staff and members of the public enjoy the night sky from the South Perth foreshore.
Credit: Dr Brad Warren (ICRAR).

When engaging others with science nothing quite cuts it like a hands-on experience for generating that 'wow' moment so vital for impact – which is why the now annual Astrofest has been such a success.

Coordinated by ICRAR and supported by a host of other organisations and groups, Astrofest takes place at Curtin Stadium and Edinburgh Oval. Each year more than 3,000 people of all ages attend to enjoy, learn and experience the largest event of its kind in the country. Astrofest is a free event featuring an astrophotography exhibition, inflatable planetariums, science shows, public talks and of course a host of telescopes pointed to the sky above.

'Nothing quite cuts it like a hands-on experience for generating that 'wow' moment so vital for impact – which is why the now annual Astrofest has been such a success.'

Based on this successful model, regional Astrofest events have begun to occur outside of metropolitan Perth, with an annual event now established and supported by ICRAR in Carnarvon and future events planned for the shires of Murchison and Mount Magnet.

Astrofest galvanises the astronomical community, bringing science communicators and educators together to deliver an event that showcases science happening in WA while connecting the public with our own awe-inspiring night sky.

Delivering events of this size and scope would not be possible without a proactive and collaborative network. To deliver Astrofest ICRAR works closely with WA's science centre Scitech, the Astronomical Group of WA, Perth Observatory, Gingin Observatory and several other entities.

GUERRILLA ASTRONOMY

Sometimes the best science experiences happen when people least expect it. ICRAR's guerrilla astronomy is about setting up telescopes in unusual places and inviting people to observe the West Australian night sky as an unexpected break in their evening.

The beauty of guerrilla astronomy is in the way it brings science to anyone. Events are not advertised and no attempt is made to gather an audience, instead telescopes are taken to where people already are; the side of a bike path, a shopping centre or an outdoor event.

Outreach staff and professional astronomers simply stand with their telescopes and wait for people to come and take a look — and people always do. People like the woman on her evening jog who got straight back in the car after seeing the Moon to get her kids and the children who would not let anyone else have a turn because they were so mesmerised by the Orion Nebula. Like the man who helped his elderly mother take her first close up look at Jupiter and its moons and his mother's gasp when the image became clear through the eyepiece.

During the guerrilla astronomy nights ICRAR's astronomers also speak to people about what they see and answer questions about astronomy and their work. The unexpected experience leaves people walking away with a newfound sense of wonder and appreciation for the Universe.

1
Pete Wheeler checks the load as the tarmac runs out on the way to the MRO.

OUTBACK ADVENTURE

Since 2009, the ICRAR Outreach and Education team have been itching to experience first hand the Murchison Radio-astronomy Observatory (MRO) and the bustle of activity in outback Western Australia.

So when the opportunity to lend a hand constructing the Murchison Widefield Array (MWA) came up, they jumped at it. In May Pete Wheeler spent eight days working as part of a four person team to clear ground, ahead of laying and tack welding more than 350 sheets of five by two metre mesh, forming the base of the 128 MWA tiles. In total more than 3,000 square metres of ground was cleared with hand tools and around nine tonnes of steel mesh was lifted, moved and put in position.

In the middle of the year Kirsten Gottschalk spent 12 days on the site as one of the supervisors of the student army, building 4,096 dipole antennas, clipping them to the expertly laid mesh tiles and cabling up the beamformers (the electronic box that actually points the telescope on the sky). A month later Kirsten returned with two students to tie up some loose ends and finish the work the student army had begun.

At the end of the year, the outreach team took their latest, and quickest, trip up to the site to show theSkyNet's anniversary prize winner around. Pete, Kirsten and Tim Young spent a day at the MRO with theSkyNet member Kim Hawtin. CSIRO treated them to an exclusive tour of the Australian SKA Pathfinder (ASKAP) and they also spent some time with the MWA science and engineering team.

Both Pete and Kirsten kept popular blogs of their time at the MRO, keeping track of their progress in photos and videos at petewheeler.wordpress.com and raspberryastro.wordpress.com.

ASPIRE TO ASTRONOMY

With its vast outback and sparsely populated regional areas, Western Australia is a perfect place for the science of radio astronomy. But while these qualities are strengths for this type of research, they create significant challenges for ICRAR's outreach and education team.

1
Aspire to Astronomy team members in the Pilbara.
2
Students use a sun spotter to record solar activity.
3
Students observe the sun through a special filter.

In 2011, in collaboration with ASPIRE, Scitech, SPICE and UWA's School of Indigenous Studies, ICRAR visited the Pilbara region to deliver astronomy themed learning experiences for students in the towns of Port Hedland, Karratha, Roebourne, Tom Price and Newman. As well visiting schools and engaging with students and teachers, ICRAR delivered observing events for each community.

Nearly 1,000 school students and 500 members of the general public participated in this major outreach initiative and, with the support of the mining companies active in the Pilbara region, each school was given a telescope with instruction and guidance for its use. These schools are now planning to bring these telescopes together to deliver observing events for Pilbara communities, a fantastic outcome and a great indicator of ongoing impact.

Programs like this are a challenge to deliver but represent unparalleled opportunities to connect with West Australians in regional areas. By delivering these programs ICRAR is encouraging scientific literacy and positive attitudes towards research, while simultaneously encouraging high school students to further their education by entering tertiary studies.

1
Dr Buzz Aldrin is interviewed by the West Australian.
2
Professor Brian Schmidt talks on ABC radio.
3
Professor Schmidt takes a question from the audience during his public lecture.

DR BUZZ ALDRIN IN WA

ICRAR outreach were involved in one of 2012's most exciting science events when Dr Buzz Aldrin landed in Western Australia to open the new Carnarvon Space and Technology Museum. The second man on the Moon charmed primary school students and adults alike as he recalled his time as an astronaut and the Apollo 11 mission that changed the course of history and inspired a generation.

ICRAR outreach staff and astronomers were asked to be part of the event and were on hand with telescopes to show the Moon and other objects in the night sky to 400 people at a VIP cocktail event with Dr Aldrin. During the function, which was attended by politicians, media, community leaders and well-known scientists, ICRAR staff projected a live image of the Moon and spoke to people about what they were able to see through the telescopes.

The Centre's involvement capped off a day in which Dr Aldrin had the whole town of Carnarvon bursting with excitement. He was met at the airport by 300 cheering children waving Australian flags and later answered questions from primary school students about the moon landing. The former astronaut shared stories about Neil Armstrong, the cramped conditions in space, trouble getting the flag to stay in the moon's rocky surface, space food and how he "peed his pants" during the seven-hour moon walk.

PROFESSOR BRIAN SCHMIDT VISIT

Over 1,000 people were inspired by astronomy when ICRAR hosted a visit from Nobel Prize winning astrophysicist Professor Brian Schmidt in September 2012.

The highlight of the three-day visit was a packed out public lecture in the 650 seat Octagon Theatre at UWA on September 5. Professor Schmidt spoke about his work and the research that won him the Nobel Prize for Physics in 2011, the discovery that the Universe was expanding at an accelerating rate. He also shared his experience of receiving the Nobel in Stockholm, Sweden, including being picked up by a driver named Stig and the loan of a princess to keep him company during the award ceremony.

Professor Schmidt gave a prime time interview on ABC radio during his visit in Perth and also spent time with smaller audiences, speaking to school students from across the city at Christ Church Grammar School, teenagers at a careers event at the State Library of Western Australia and a breakfast for professional science communicators.

You don't have to be a Nobel Prize winner to share a love of science — some of ICRAR's outreach highlights were down to the infectious enthusiasm of the Centre's young postgraduate students.

STUDENT HIGHLIGHTS

PhD student Florian Beutler gave an entertaining presentation about his research as part of TED's worldwide talent search for the best minds and ideas. His talk "Does Earth have a special place in the Universe?" was given at TED@Sydney in May 2012 and he amazed the audience with his work looking at the distribution of galaxies in the Universe and testing Einstein's theory of general relativity by measuring the gravitational interactions between galaxies. Florian also walked the audience through the concepts of dark energy, dark matter and the possibility of other dimensions in our Universe, all in less than seven minutes.

PhD student Mehmet Alpaslan is working to inspire the next generation of young researchers as the 2012 "Scientist in Residence" at Christ Church Grammar School in the Perth suburb of Claremont. The initiative, supported by the Christ Church Parents' Association, meant Mehmet was able to give lectures in astronomy and cosmology for students and speak to teachers and the wider school community. He also delivered practical classes with the students where they calculated the mass of a galaxy and used a portable radio telescope to work out the temperature of the Sun's corona.

PhD student John Goldsmith's research project "Cosmos, Culture and Landscape", now in its 3rd year, investigates the sharing and communication of Australian Aboriginal astronomical knowledge in today's society. This research is inspired by ICRAR's collaboration with Murchison Aboriginal artists and elders associated with the Murchison Radio Observatory. ICRAR's collaboration with Yamaji Art led to the "Ilgarijiri - Things Belonging to the Sky" project and internationally touring exhibition.

When he's not working on his PhD thesis John is a world renowned Astrophotographer, travelling near and far to capture breath-taking imagery that inspires the public and helps to communicate the work of our astronomers and astrophysicists.

1
PhD candidate Mehmet Alpaslan explains how to measure the temperature of the sun to students at Christ Church Grammar School.

1
A sign post point from the site of the Murchison Widefield Array to it's 13 collaborating institutions.

COLLABORATION

1
Australian-New Zealand SKA site bid team in London for final interviews - December 2011 From left to right: Professor Peter Quinn (ICRAR), Patricia Kelly (DIISRTE), Dr Bryan Boyle (CSIRO), Professor Phil Diamond (SKAO), Dr Michelle Storey (CSIRO), Trevor Danos (Corrs Chambers Westgarth).

COLLABORATION

ICRAR is an international organisation that is now strongly connected to astronomical science and technology research worldwide and to the community developing the systems and tools necessary to realise the SKA. We have developed collaborations at the national and international level with organisations and industries to ensure our efforts and investments have maximum impact. With the decision to host the entire SKA-low facility in Australia, ICRAR is ideally placed to work closely with the international SKA and astronomical communities to ensure we make the most of the new view of our Universe that SKA-low will provide.

National Collaboration

On the Australian national stage, ICRAR has formed strong collaborations with established and emerging research and engineering communities. Foremost of these collaborations is ICRAR's strong partnership with CSIRO and the research teams based at the CSIRO Centre for Space Science (CASS) in Sydney. Working with CSIRO engineers and scientists, ICRAR is contributing to the development of ASKAP capabilities and the design of the astronomical survey projects that will have a significant impact on forefront research problems in modern astronomy and astrophysics. ICRAR Director Professor Peter Quinn also works closely with Professor Brian Boyle and Professor Phil Diamond from CASS as part of the Australian/NZ SKA Coordination Committee (ANZSCC). This committee brings together the state and federal governments of New Zealand, Australia and Western Australia to coordinate the Aus/NZ effort for the international SKA project.

Our collaboration with the CAASTRO ARC Centre of Excellence for All-sky Astrophysics embodies the strong national research bridges ICRAR wants to form to advance Australian astronomy. As the largest community member of the CAASTRO collaborating organisations (University of Sydney, Melbourne University, Australian National University and Swinburne University), ICRAR will participate in all three major research themes of CAASTRO and will employ 15 of the 42 positions funded through CAASTRO. ICRAR sees CAASTRO as an ideal mechanism to join optical and radio communities in Australia and for Australia to prepare to take on leading roles in astronomical survey science that will dominate the international research agenda in the next 10-20 years.

The International SKA Project

The ICRAR science, engineering, ICT and Murchison Radio-astronomy Observatory programs are all focused on activities that inform the international SKA effort, in some cases tackling difficult issues that are not being addressed elsewhere in Australia or within the international SKA consortium. The following are examples of activities undertaken and contributions made by ICRAR staff within the international SKA effort.

- ICRAR actively contributed to the Australian/New Zealand response to the request for information issued to candidate site countries by the international SKA project. ICRAR has coordinated the WA input, working together with the WA Department of Commerce and Department of Premier and Cabinet, also working collaboratively with various Federal Government agencies, primarily the Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE).
- ICRAR has actively contributed to the SKA Forums, and in the fourth international SKA Forum gave numerous presentations and interviews that included Steven Tingay's contribution to the main Australia/NZ presentation on 6 July (together with Senator Carr, Brian Boyle and Lisa Harvey Smith).
- ICRAR Deputy Directors are actively contributing to several SKA national and international scientific and technical committees.
- Over 40% of ICRAR's postgraduates have been recruited internationally through competitive processes and the high quality postgraduates are actively working on a range of SKA design and science programs.
- Professors Peter Quinn and Peter Hall are among the co-authors on the SKA Program Execution Plan that defines the SKA project activities in the pre-construction period from 2012-2015.
- A major focus of the ICRAR ICT program is the conceptual design of the SKA data system based on ICRAR staff experience with other large data intensive projects (like the European Southern Observatory's Very Large Telescope and the Atacama Large Millimeter Array) and the ICRAR ICT project effort to demonstrate a data intensive research pathfinder utilising Pawsey Centre resources.

- A major focus of the ICRAR engineering program is a contribution to the Aperture Array Verification Program (AAVP), which will be the primary path for developing the SKA Phase 1 low frequency technology. As part of this effort an AAVP prototype will be deployed at the MRO during the SKA pre-construction period.
- Several ICRAR staff contributed to the crucial suite of SKA Concept Design Reviews (CoDRs) for various SKA sub-systems, including: low frequency aperture arrays; digital systems; software systems.
- ICRAR's largest single project by value and scope is the support of the Murchison Widefield Array (MWA), a $50 million low frequency array consisting of 128 antennas located at the MRO. The MWA is one of only three SKA Precursor instruments (ASKAP and MeerKAT are the other two). As an SKA Precursor, the MWA has responsibilities to feed technical and scientific lessons learnt into the international SKA project. This is primarily done via staff at both ICRAR nodes working on the MWA.
- ICRAR Deputy Director Professor Peter Hall is the Chair of the SKA Power Investigation Taskforce, the group exploring the particularly challenging area of power provision for the SKA.
- ICRAR staff are closely engaged in the technical aspects of international linkages via Very Long Baseline Interferometry, particularly into China, Japan, Korea and India. ICRAR hosted a meeting (financially supported by DIISRTE) that brought together scientists from these counties and others to discuss the SKA long baselines and the benefits of extending an Australia – New Zealand SKA into Asia. ICRAR has been driving these close international SKA connections in the Asian region.
- ICRAR hosted an international SKA planning meeting and workshop for the design and development of the SKA Phase 1 low frequency aperture array system, in preparation for the SKA pre-construction phase over the next three to four years. ICRAR is driving this major system for the international SKA project, primarily via Professor Peter Hall's effort.
- Dr Minh Huynh (an ICRAR staff member) has been appointed as the Deputy International Project Scientists for the SKA and spends 50% of her time at the SKA Program Development Office (SPDO) in Manchester directly supporting the development of SKA science cases and requirements.

1
This graphic shows the many ground and space based facilities contributing to the GAMA survey. GAMA is unique in sampling such a broad range of the electromagnetic spectrum covering: x-ray, ultra-violet, optical, infrared and radio wavelengths. These data will be used to study the entire energy output for a sample of 380,000 galaxies.

International Astronomy

ICRAR's Director Peter Quinn and Deputy Directors Steven Tingay, Lister Staveley-Smith and Peter Hall are all internationally renowned astronomers and engineers and at the inception of ICRAR brought a wealth of existing collaborations to Western Australia, in diverse but complementary areas. The strength of ICRAR is built around this diversity and complementarity. In addition, with the support afforded ICRAR, the scope of ICRAR's national and international collaborations have multiplied and after a little over three years, ICRAR is the most internationally well-connected centre for radio astronomy in Australia. ICRAR's international collaborations extend all over the world, to every country involved in the SKA and radio astronomy. A particular focus that has emerged for ICRAR has been collaboration with countries in our region. We are focusing particular attention on the emerging powerhouses in science and economics, China and India. The 50-year lifetime of the SKA will see China, in particular, rise to be an elite country in the physical sciences and high performance computing.

THE FOLLOWING ARE SOME EXAMPLES OF ICRAR'S LARGE AND GROWING SET OF INTERNATIONAL ASTRONOMY COLLABORATIONS.

- **Galaxy and Mass Assembly (GAMA) Project:** In February 2011, ICRAR successfully appointed Professor Simon Driver who brings co-ownership of the GAMA project to ICRAR. This high profile, multi-wavelength international survey significantly broadens activity in ICRAR's science program, enhances national and international links, and will position ICRAR to be a world-class research centre for galaxy evolution studies and survey science in general. *The facilities and organisations involved in the GAMA survey project can be seen in the diagram opposite.*
- **Murchison Widefield Array Project:** ICRAR is a significant contributor to this project, managed by ICRAR Deputy Director Steven Tingay. This $50 million SKA precursor is ICRAR's largest collaborative project. The project consortium consists of seven Australian universities, CSIRO, two divisions of MIT, Harvard University, the Raman Research Institute in India, Victoria University of Wellington in New Zealand, plus a range of secondary academic and industry partners. The Curtin node of ICRAR raised over $2 million last year to kick-start the final stages of construction.
- **Australia India Strategic Research Fund:** Professor Steven Tingay leads a federally-funded bi-lateral program with Indian radio astronomers at the Raman Research Institute in Bangalore.
- **Pathfinders HI Survey Coordination Committee:** As chair of this committee, ICRAR has co-organized three international meetings involving science teams from the University of Cape Town, ASTRON, the University of Groningen and CSIRO. These meetings have resulted in proposed coordinated HI surveys for the major pathfinder telescopes. ICRAR also collaborates with a number of individual organisations.
- **Cambridge University (United Kingdom):** ICRAR works closely with colleagues at the Cavendish Laboratory to develop next generation SKA performance and cost estimation tools, facilitating detailed design of the initial phases of the SKA. PhD graduate Dr Tim Colegate has made extended visits to Cambridge and the SKA Program Development Office to progress this collaboration.
- **International VLBI and e-VLBI:** ICRAR is the hub for VLBI and e-VLBI in Australia, a technique that allows connections between telescopes all around the world. Professor Steven Tingay and his team have undertaken science observations by connecting Australian telescopes to Indian telescopes for the first time, and have performed numerous experiments between Australia and China in collaboration with the VLBI team in Shanghai. In ICRAR II a particular focus will be an expansion of this program with China and India.
- **Oxford University (United Kingdom):** A fruitful PhD student exchange and co-supervision program has commenced with the Department of Astrophysics. Students Jacinta Delhaize (ICRAR) and Danny Price (Oxford) have undertaken reverse visits. ICRAR has also funded a joint study, with iVEC and Oxford, on the application of cloud computing to the processing and data management challenges of the SKA.
- **Max Planck Institute for Nuclear Physics (Germany):** Under a Go8/DAAD scheme, researchers from ICRAR and the Max Planck Institute have received funding for a two-year program of exchange visits. These visits will improve understanding of the generation of radio emission from expanding supernova shock fronts.
- **NASA Jet Propulsion Laboratory (United States):** ICRAR and the NASA Jet Propulsion Laboratory in California are developing new hardware and software to search for fast radio transients. This will initially be used with existing telescopes around the world, and the technology will eventually be deployed on ASKAP and inform a major aspect of the SKA project.

1
The diagram opposite describes the organisational relationships established by the ICRAR ICT team and the type of work being delivered. The type of the relation is indicated by the colour of the boxes holding the names or acronyms of the organisations. The colour coding is explained in the legend below the diagram. The work areas are highlighted by the arrows pointing to the various ICT activities and projects.

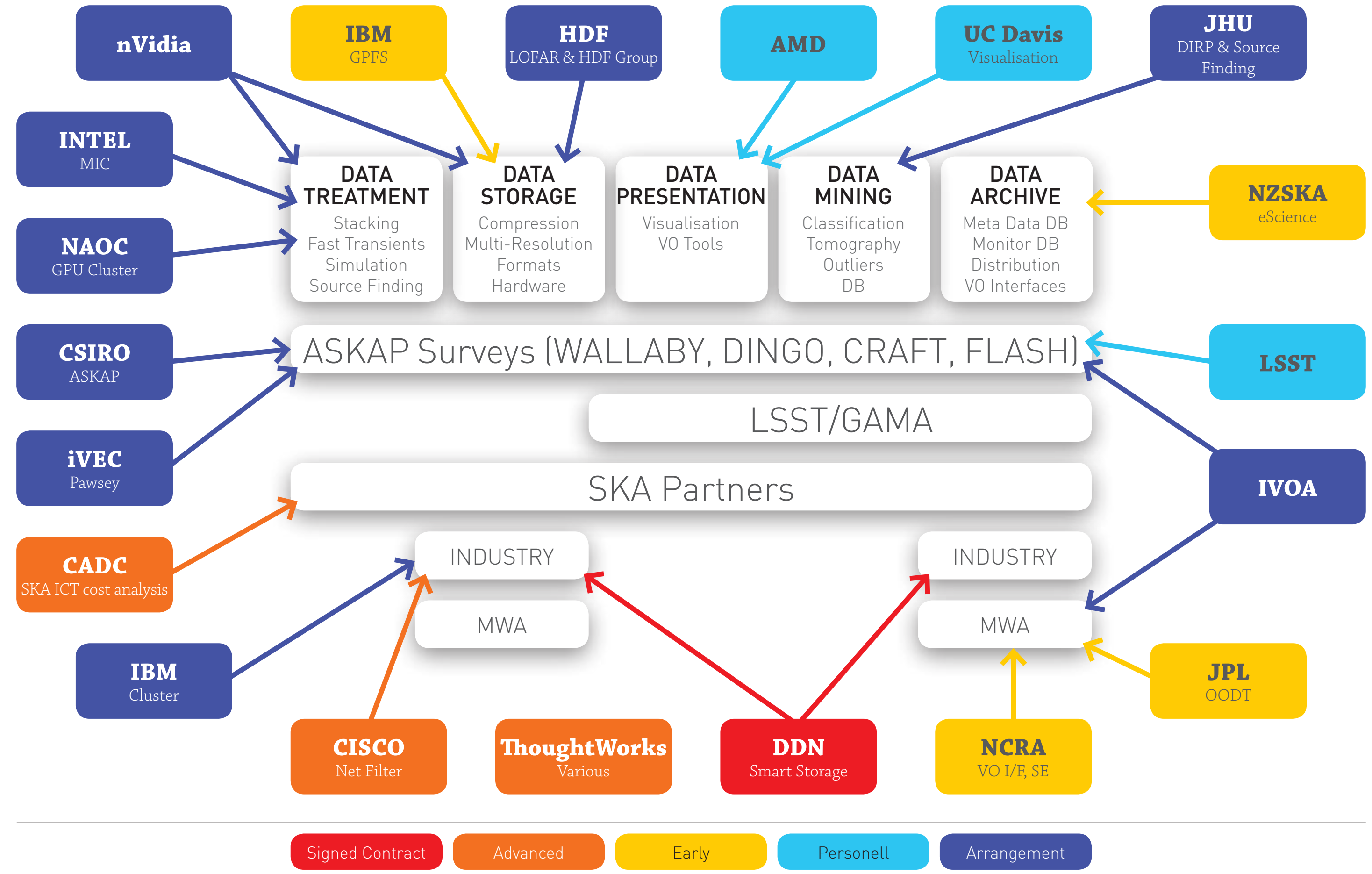
- **Large Synoptic Survey Telescope (US/Chile):** The Large Synoptic Survey Telescope is the highest priority optical astronomy project for the US community this decade. It will survey the entire sky every three nights and produce a catalogue of stars and galaxies containing over one billion objects. ICRAR and the Large Synoptic Survey Telescope have signed an agreement to fund a shared research position to investigate database technologies relevant to both the Large Synoptic Survey Telescope and the SKA. This will lay the basis for optical and radio research using the SKA precursors and large optical surveys.
- **Proactive planning for participation in the SKA Project Execution Plan (PEP):** ICRAR's AAVP and the ICT teams are proactively engaged with industry and academia to develop small collaborative projects to enable development of working relationships and the creation of working environments with a view to developing longer term proto-consortia for participation in the PEP.

A map of the organisational relationships being developed with industry and academia in advance of opportunities for SKA pre-construction opportunities in ICT can be seen opposite.

Industry

ICRAR is primarily a research organisation but, rather distinctively, one with a strong development mandate under its engineering and ICT programs. Such development allows ICRAR's astronomers to conduct leading-edge scientific investigations with existing radio telescopes and will give them early access to SKA pathfinders and, eventually, the SKA itself. ICRAR has long recognised that industry will build, and possibly operate, the SKA. To ensure that many of the innovations developed by ICRAR are scalable to the SKA, ICRAR has worked to ensure early involvement by industry in a number of its projects. In addition, the Centre has promoted strongly the role of industry in Australian and international forums, and has been a leading developer of industry policy in these arenas. To date, ICRAR has channeled $4.74 million into industry engagement as part of SKA and precursor activities.

- ICRAR is a full member of the Australasian SKA Industry Consortium (ASKAIC) and is represented by Professor Peter Hall on this body. Two important strategic priorities for ICRAR have been leadership within discussions designed to frame Australia's involvement in the SKA pre-construction (PEP) phase, and those relating to greater engagement by SMEs (including WA SMEs) in ASKAIC.
- Internationally, ICRAR PhD graduate Philip Crosby and Professor Peter Hall have formulated and published a number of criteria and early-intervention techniques for successful management of mega-science projects, such as the SKA. Dr Crosby is a CSIRO employee and spent two years working in the international SKA Program Development Office in Manchester, an initiative supported in part by ICRAR.
- ICRAR has developed several important operational industry links, each of which is designed to foster joint capacity in key SKA development areas. These include:
  - An agreement with IBM Australasia to investigate computing solutions relevant to the SKA and its pathfinders.
  - ICRAR provides opportunities for staff from ThoughtWorks (a global IT company with offices in Perth – three staff one day per week) and Systemic (a Perth-based SME IT company – also three staff one day per week) to spend time working on ICRAR projects. This provides professional development opportunities and the chance for industries to understand the SKA problem space in advance of PEP consortia activities and/or future tender opportunities.
  - ICRAR has developed a strong relationship with WA-based SME Poseidon Scientific Instruments (PSI) (now part of Raytheon) which has resulted in:
    - A contract to develop and supply the prototype field version of the MWA digital receiver.
    - An R&D agreement in the context of ICRAR's global Epoch of Reionization engineering project.
    - An agreement to define the company's involvement in the prototyping of low-frequency sparse aperture array facilities likely to be built in WA as part of the PEP.
    - The awarding of a $1.3 million contract (from federal funds) to build the 16 packages of sensitive electronics required by the 128 tile MWA.
    - Collaboration with NVIDIA as an NVIDIA Research Centre (from March 2011), including a grant of a number of high-end GPU processors for SKA design and Data Intensive Research Program activities.
    - ICRAR's ICT team is part of the executive team of the Science Data Processor pre-consortium tasked with defining the structure for this important work package. ICRAR will commit substantial resources towards this consortium as work commences in 2013. In parallel the ICT team will continue to broaden and develop relations with local and global industry partners such as CISCO, DDN, Intel, ThoughtWorks, Systemic, Kakadusoftware and IBM.



ICRAR will continue to provide opportunities for local enterprises to be involved in high visibility SKA development work, to foster partnerships between SMEs and large transnational companies, and to grow the scope for commercial investment in instrumentation and related projects. As an R&D organisation, ICRAR can play a particularly valuable role in exposing commercial players to the leading-edge technology and techniques pioneered in radio astronomy. Feedback from industry suggests that personnel exchange, via short to medium-term placements, represents a particularly valuable way of achieving this. Some exchange is already occurring in ICRAR's engineering and ICT projects and, in the course of the early-stage PEP work, more will be evident.

ICRAR has channelled $4.74 million into industry engagement as part of SKA and precursor activities.

Achievement 2011–2012

STAFF AND STUDENTS

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ICRAR engineering students test antenna prototypes in an anechoic chamber.


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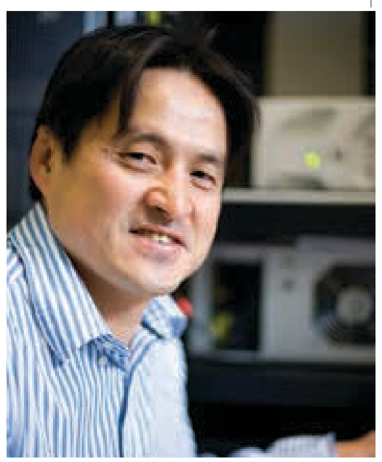
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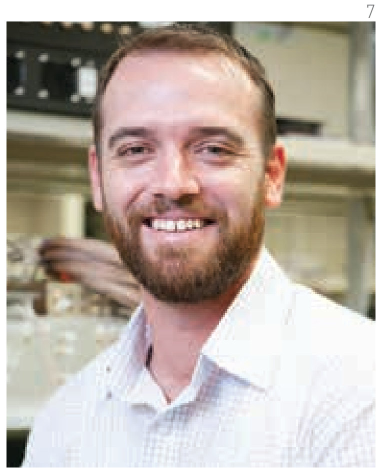
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Mehmet Alpaslan
PhD Candidate, Oct-11
Optical and near-infrared galaxy filaments in the Galaxy and Mass Assembly survey

2
Balwinder Arora
PhD Candidate, Oct-12
Ionosphere Faraday Rotation, it's Estimation and Mitigation for Radio Astronomy Applications

3
Alex Beckley
theSkyNet Web Programmer and Analyst, Dec-12
Website design, programming and analysis. Science communication

4
Prof Kenji Bekki
Research Professor, ARC Future Fellow, Jan-10
Formation and evolution of galaxies and globular clusters

I create galaxies and globular clusters in computer simulations in order to better understand the origin of these objects.

5
Dr Florian Beutler
PhD Graduate, Sep-09
Cosmology with the 6dF Galaxy Survey

Pulsars are among the most fascinating objects in the Universe. They enable us to study a wide range of fundamental physics and astrophysics. I observe and research pulsars using various large radio telescopes. I am currently conducting research to search for new pulsars, and do timing studies to test the theories of gravity and study short-duration astrophysical phenomena such as giant radio pulses.

6
Dr Ramesh Bhat
Curtin Research Fellow, Jun-12
High Time Resolution Radio Astronomy

Pulsars are among the most fascinating objects in the Universe. They enable us to study a wide range of fundamental physics and astrophysics. I observe and research pulsars using various large radio telescopes. I am currently conducting research to search for new pulsars, and do timing studies to test the theories of gravity and study short-duration astrophysical phenomena such as giant radio pulses. I am also a member of the MWA science commissioning team and we are developing high time resolution science capabilities for this instrument which will open up new avenues for exciting science at low frequencies.

7
Dr Hayley Bignall
Postdoctoral Research Fellow, Sep-09
High Angular Resolution Radio Astronomy

I study jets in active galactic nuclei at the highest angular resolution, using Very Long Baseline Interferometry (VLBI) and interstellar scattering. I'm also interested in transient radio sources, the interstellar medium and various other applications of VLBI. I run the correlator for the Australian Long Baseline Array.

8
Dr Jan Geralt Bij de Vaate
Senior Research Fellow, Sep-10
Aperture Arrays

I assist with design of the low frequency Aperture Array of the SKA with a research focus on active antennas.

9
Robin Boddington
Aboriginal Liaison Officer, Oct-09
Liaison

10
Tom Booler
MWA Project Manager, Feb-11
Project Management

11
Mark Boulton
IT Officer, Aug-11
IT Infrastructure design and deployment

I help staff and students achieve their IT related outcomes by supporting some of the systems they use. I also look for innovative solutions to IT problems in the hope of giving us an edge.

12
Sarah Bruzzese
PhD Candidate, Mar-12
The initial mass function of nearby galaxies


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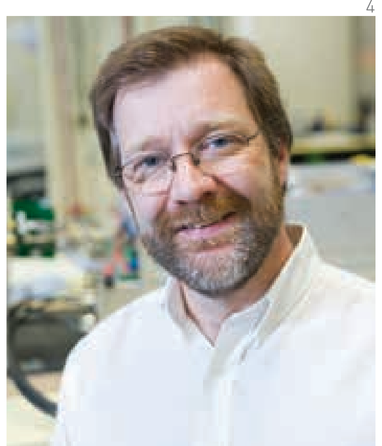
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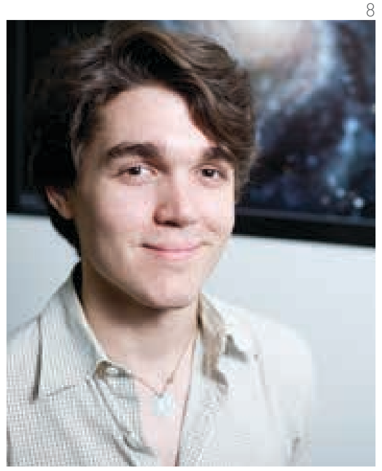
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1
Alessio Checcucci
Research Associate, Oct-11
Database Technologies

I work on the management of large multi-wavelength catalog databases on behalf of the ICRAR/LSST collaboration.

2
Cdr. Chittawan Choeysakul
PhD Candidate, Jul-11
Characterisation and Design of a Reverberation Chamber for Electromagnetic Emission Measurements for Radio Astronomy Applications

3
Shin Kee Chung
Research Associate, Apr-11
GPU Programming

Observatories for astronomy research produce a lot of data every single second, and different research in astronomy requires different algorithms to analyse the data. The processing power available is not yet able to catch up with the data rate. I specialise in GPUs which are very cost efficient in terms of floating-point operations per dollar spent. This will allow everyone to be able to perform their own analysis on the data without spending millions of dollars for a super computer.

4
Dr Nathan Clarke
Research Engineer, Apr-10
Digital systems for high time resolution radio astronomy

I am an electronics engineer and my current interest is in designing digital systems to search for time varying astronomical radio emissions such as giant pulses and gamma-ray bursts.

5
Tim Colegate
PhD Candidate, Sep-09
System design for the Square Kilometre Array: New Views of the Universe

6
Dr Phil Crosby
Researcher, Sep-09
Success drivers for mega-science projects

I undertake research into large science and engineering projects e.g. the SKA, ALMA , and GMT programs. My work focuses on practical management approaches that lift success with complex project delivery.

7
Brian Crosse
MWA Commissioning Engineer, Jan-11
Radio Astronomy Engineering

I am one of two engineers tasked to install, do engineering commissioning, and support the Murchison Widefield Array (MWA) low frequency radio telescope. My job involves frequent trips to the remote Murchison Radio Observatory and a lot of having my head stuck inside an electronics cabinet or in front of a computer terminal. We're responsible for turning the faint radio signals from space into ones and zeros. We then pass them to the scientists to work out what they mean.

8
Dr Peter Curran
Postdoctoral Researcher, Aug-12
Observations of X-ray binaries

I use various space and ground based telescopes to study X-ray binaries. Though they are named X-ray binaries, these black-hole systems actually emit at wavelengths all along the electromagnetic spectrum from radio waves through to visible light and up to X-rays. By combining data from all these wavelengths we can investigate how matter falling into the black hole behaves in the extreme environment around a black hole and how the system accelerates plasma to relativistic velocities.

9
Lara DeLacour
IP and Commercialisation Manager, Sep-12
Contracts/IP Manager – facilitator of university research and commercialisation activities

10
Jacinta Delhaize
PhD Candidate, Sep-09
Studies of galaxy evolution in intermediate-redshift galaxies using stacking techniques

11
Jonathan Diaz
Masters Graduate, Feb-10
Simulations of the Magellanic Stream

12
Dr Richard Dodson
Research Fellow, Sep-09
Astronomical techniques

I study the birth and end points of stars, using a variety of radio astronomy techniques. In the SKA era I find myself developing these methods for the next generation of instruments and high performance computing.


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1
Prof Simon Driver
Winthrop Research Professor, Feb-10
Extragalactic Astronomy

The Universe began from pure energy, some of which has been transformed into an array of structures ranging from superclusters, filaments, groups, active galactic nuclei, galaxies, super-massive black holes, stars, dust, and molecules. I lead the extragalactic group which seeks to study these structures at all wavelengths in order to understand the physical processes which led to their formation.

2
Dr Robert Duffin
Super Science Fellow, Nov-10
Solar Science

3
Dr Alan Duffy
Postdoctoral Research Fellow, Sep-09
Galaxy Formation and Cosmology

I use powerful supercomputers to create model universes, enabling me to see the change and growth of galaxies from the Big Bang to the present. By changing the physical laws in this universe-in-a-box we can create predictions that are tested by the images we obtain from radio telescopes, allowing us to probe key cosmological parameters like the nature of Dark Matter and Dark Energy.

4
Angela Dunleavy
Administrative Coordinator, Jun-12
Administration

I am the Administrative Coordinator for ICRAR-Curtin.

5
Dr Wiebke Ebeling
CAASTRO Education & Outreach Coordinator, Jul-11
Science Communication, Astronomy Outreach

CAASTRO members are based at six collaborating Australian universities and at national and international partner organisations. It is my responsibility to communicate our science to the public through press releases, outreach activities and social media and to manage school engagement and mentoring programs that inspire the next generation of scientists.

6
Dr Ed Elson
Super Science Fellow, Dec-10
Observations of nearby galaxies

I observe galaxies at various wavelengths to build up a complete picture of the processes at work. Among other things I study the dark matter content of galaxies and their star formation properties.

7
David Emrich
MWA Commissioning Engineer, Sep-09
Hardware/ Software/ Systems Engineering, Logistics, Safety, Fieldwork planning and execution

I am 100% focused on the Murchison Widefield Array radio telescope being commissioned this year and going into operations next year. My job involves anything and everything to do with field operations, installation, assembly, testing, configuring software, and mechanical installations.

8
Dr John Flexman
Research Officer, Feb-10
RF, System Design, Signal Processing

I work in two roles as a program manager for ICRAR engineering and as a research officer in the Sparse Antenna Array programme. I am currently working on antenna testing methods and technology.

9
Dr Bi-Qing For
John Stocker Postdoctoral Fellow, Aug-11
Magellanic System, High-Velocity Clouds

I study the interaction between the Magellanic System and the Milky Way using HI data. The primary aim is to study the morphology and properties of the high velocity clouds associate with the Magellanic System and compare them with the theoretical models.

10
Derek Gerstmann
PhD Candidate, Jun-10
Ultra-scale visualisation with adaptive resource management for data intensive scientific research

11
Owen Giersch
PhD Candidate, Sep-09
Automated Solar Feature Detection and Analysis

12
Mark Glossop
MWA ICT Systems Engineer, Sep-09
MWA Software Engineering and Systems Administration

I'm part of the engineering team working to build and commission the Murchison Widefield Array radio telescope. As an "IT generalist", I'm involved in both software development and system operations."


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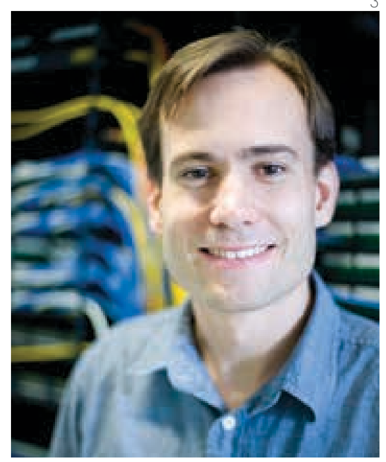
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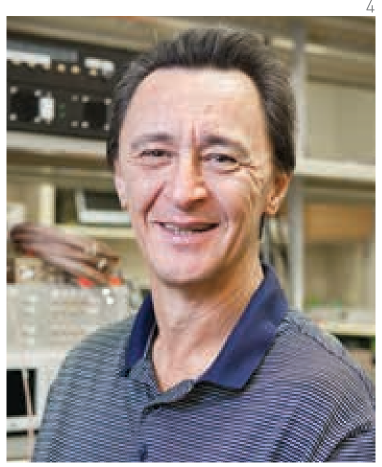
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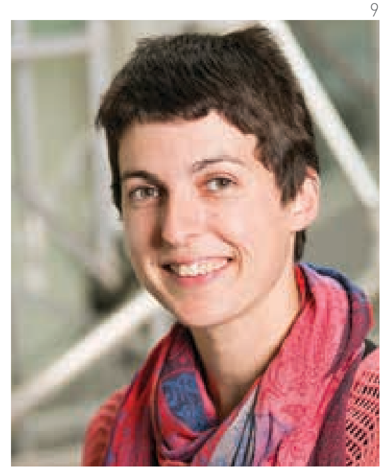
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1
Dr Leith Godfrey
Research Fellow, May-10
Radio astronomy, active galaxies

I use radio and X-ray telescopes to study the emission from active galaxies. Modelling this emission allows me to determine the properties of the jets of plasma produced by the central supermassive black holes in active galaxies.

2
John Goldsmith
PhD Candidate, Aug-09
Cosmos, Culture and Landscape. Documenting, learning and sharing Aboriginal astronomical knowledge in contemporary society

3
Leanne Goodsell
Administrative Assistant, Nov-10
Administrative functions

I provide over the counter and telephone client services, including greet and direct visitors, I also assist with staff security and entry protocols. Help with organisation of seminars, meetings, conferences and support visitors. Distribute mail, and manage courier dispatches and deliveries. Additional to this I also undertake online purchasing & procurement.

4
Kirsten Gottschalk
Outreach and Education Officer, Jan-10
Science Communication

The ICRAR outreach team makes sure everyone possible knows about the great work that our staff and students are up to. I manage the ICRAR website, Facebook and Twitter, visit schools and communities to talk about astronomy and the SKA, act as media contact, am a human spokesperson of theSkyNet, coordinate public astronomy events like the annual Astrofest and morph into a guerrilla astronomer on random summer nights. In short, I have a great time at work!

5
Prof Peter Hall
Deputy Director (Engineering), Sep-09
Radio astronomy engineering

I am responsible for the strategic and operational aspects of ICRAR's engineering program. My personal research includes new technologies for the SKA, as well as international SKA system design activities. I am also heavily involved with industry engagement initiatives for the SKA.

6
Dr Christopher Harris
Research Associate, Sep-09
Parallel Signal and Image Processing

I lead ICRAR's HPC for Radio Astronomy project. In this role, I work with ICRAR scientists and students to develop hardware-matched scientific algorithms to support their research. I also teach courses in Computer Architecture and GPU Programming.

7
David Herne
PhD Candidate, Sep-09
High Fidelity Mapping and Calibration of the Ionosphere to Low-Frequency Radio Waves

8
Tao Hong
CAASTRO PhD Candidate, May-11
Cosmological Structure and HI Observations

9
Shaun Hooper
PhD Candidate, Jan-11
Low-Latency Detection of Gravitational Waves for Electromagnetic Follow-up

10
Laura Hoppmann
PhD Candidate, Aug-10
Evolution of the gas content of the Universe

11
Claire Hotan
Masters Graduate, Sep-09
Testing a potential new site for an optical telescope in Australia

12
Dr Natasha Hurley-Walker
Super Science Fellow, Aug-11
MWA Calibration and Imaging

I work on new data from the Murchison Widefield Array, improving the calibration and imaging of low-frequency interferometric data. I'm also observing radio sources such as supernova remnants and distant radio galaxies.


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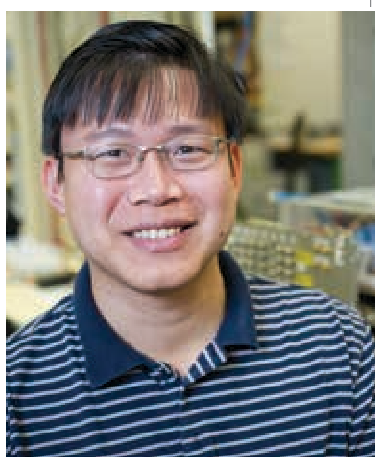
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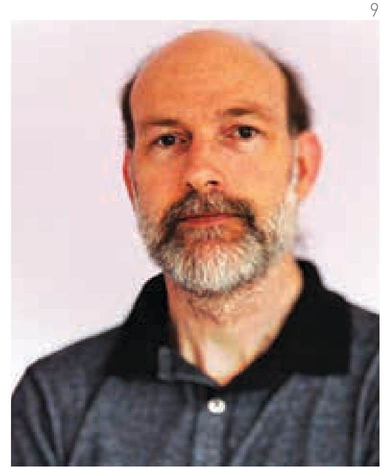
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Dr Minh Huynh
Research Associate Professor, Oct-10
High redshift galaxies and AGN, formation and evolution of galaxies and multiwavelength surveys

I am an astronomer studying galaxy formation and evolution through deep multiwavelength surveys. I am also the Deputy International SKA Project Scientist, and in that position I am helping the SKA project develop its science case, and am the link between the SKA engineers and astronomers.

2
Aziz Jiwani
PhD Candidate, Sep-09
Conical spiral antenna for the Square Kilometre Array—A feasibility study

3
Tanya Jones
Administrative Coordinator, Apr-11
Administration

4
Dr Budi Juswardy
Research Engineer, Jan-11
RF Circuit Design and Renewable Energy

I am involved in the design, testing and characterisation of front-end radio astronomy receiver building blocks, such as low-noise amplifiers (LNAs) and radio-over-fibre (RoF); and also evaluating renewable energy technologies to power those circuitry at the front-end.

5
Rachel Kennedy
Administrative Assistant, Jul-11
Administration

My role is to assist the Curtin node with administration requirements including event management, travel arrangements and welcoming visitors.

6
A/Prof Slava Kitaeff
Research Associate Professor, May-11
High Performance Computing

I'm working as part of ICRAR's Data Intensive Research Program. My interests are broadly in HPC, data organisation, and software engineering for SKA. I'm also part of GEG MWA collaboration with the interests in galactic diffuse ISM and RRL.

7
Dr Kevin Koay
PhD Graduate, Sep-09
Interstellar and Intergalactic Scattering as Astrophysical Probes

8
Kathy Kok
Finance & Administration Officer, Jan-10

I handle the financials and administrative tasks that are required to ensure the smooth operation of ICRAR.

9
Dr Nadia Kudryavtseva
Super Science Fellow, Dec-10
Transients, Low-frequency radio astronomy, Active Galactic Nuclei

I study variable sources and search for transient events with Murchison Widefield Array. I'm also part of the MWA science commissioning team.

10
Rebecca Lange
PhD Candidate, Jun-12
Multiwavelength Galaxy Survey - GAMA.

11
Katie Lau
Administrative Officer, Apr-11
Administration and Finance

I am the Administrative Officer for the ARC Centre of Excellence for All-sky Astrophysics (CAASTRO). I work closely with the CAASTRO Deputy Director to provide administrative support that includes the management of the accounting and purchasing needs of the Centre, the monitoring of its annual budget and the preparation of financial reports.

12
Chris Lord
Masters Student, Sep-09
A Low Frequency Array of Simple Radio Telescopes for the Detection of Solar X-Ray and Radio Flares, and the Study of the Ionosphere


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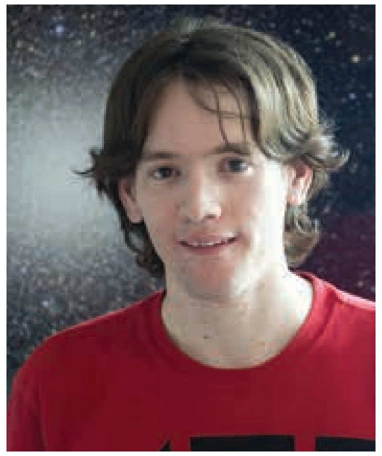
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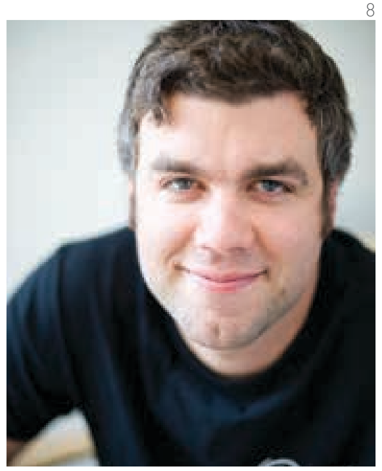
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Paul Luckas
Masters Student, Jun-10
Not just pretty pictures: The design, deployment and use of an internet accessible, robotic optical telescope for student research projects

2
Damien MacPherson
PhD Candidate, Mar-12
Gamma-Ray Bursts from the early Universe

3
Dr Jean-Pierre Macquart
Teaching and Research Fellow, Sep-09
Theoretical Astrophysics

I work on a broad range of topics encompassing Active Galactic Nuclei, pulsars, interstellar and intergalactic propagation effects and radio transients.

4
Jurek Malarecki
PhD Candidate, Feb-10
The Warm-Hot Intergalactic Medium

5
Yolandie McDade
Executive Assistant, May-11
Administrative support to the executive team

I provide administrative support to the Director which includes day to day meeting scheduling, travel arrangements, meeting and events coordination and other ad-hoc duties as required by the Director and the executive team.

6
Prof Gerhardt Meurer
Winthrop Research Professor, Jan-10
Star formation, dark matter and their roles in the evolution of galaxies

I perform multi-wavelength studies of galaxies to determine how they evolve. I am particularly interested in galaxies in the nearby Universe where the distributions of the stars, gas and dark matter can be mapped in detail.

7
Dr Martin Meyer
Research Associate Professor, Sep-09
HI Surveys, Galaxy Formation and Evolution

I study galaxy formation and evolution as part of the research staff at ICRAR, with a particular focus on understanding the role played by neutral hydrogen gas. I am the PI of DINGO, a deep HI survey planned for ASKAP.

8
Scott Meyer
PhD Candidate, Feb-11
Investigating the Tully-Fisher relation and galaxy kinematics through neutral Hydrogen spectral line stacking techniques

9
Dr James Miller-Jones
Research Fellow, Jul-10
X-ray binaries and slow transients

I work on the connection between inflow and outflow around accreting compact objects, focusing particularly on stellar-mass black holes, and aiming to understand the origin and nature of relativistic jets in these systems. I am also involved in the LOFAR and MeerKAT key science projects on slow transients.

10
Aquib Moin
PhD Candidate, Sep-09
Observational study of transients associated with GRBs and XRBs using e-VLBI/VLBI

11
Dr John Morgan
Research Fellow, May-10
Very Long Baseline Interferometry

I work in research on wide-field VLBI. VLBI is the highest-resolution imaging technique in Astronomy. Wide-field VLBI combines this with a large field of view, producing images of small patches of sky up to a terapixel in size.

12
Mehran Mossammaparast
Masters Student, May-11
Radiometric Receiver for Measuring Red-Shifted 21cm Hydrogen Monopole During EoR


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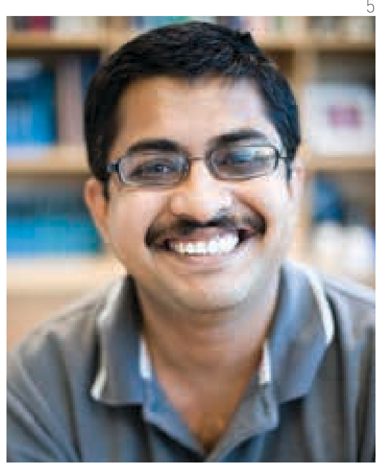
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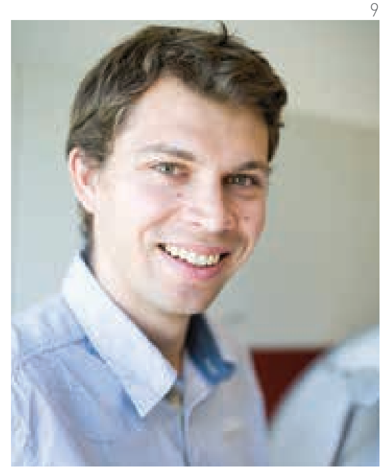
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1
Steven Murray
PhD Candidate, Apr-12
Non-Parametric Descriptions of Dark Matter Haloes

2
Russell Nicholls
IP and Commercialisation Manager, Sep-12
Intellectual Property and Commercialisation

3
Dr Danail Obreschkow
Research Associate Professor, Oct-11
Cosmology

My research involves three fields in extragalactic astronomy. Firstly, I study how matter is distributed in the Universe. Secondly, I investigate how stars formed over the history of time. Thirdly, I am actively contributing to the preparation of surveys with future radio telescopes, such as the Square Kilometre Array and its Australian and South African pathfinders. Incidentally, I also spend some of my time flying in weightlessness aboard the Airbus A300 zero-g to study the mysteries of bubbles!

4
Dr Se-Heon Oh
CAASTRO Research Assistant Professor, May-11
Galaxy dynamics; Dark matter in galaxies; HI galaxy survey

I have been working on defining a strategy and developing a pipeline for extracting kinematic parameters from a significant number of resolved galaxies from the ASKAP WALLABY survey. In addition, I have been studying dark matter distribution in galaxies using multi-wavelength data set from several HI galaxy surveys, like THINGS, LITTLE THINGS and LVHIS as well as some of the ASKAP and MeerKAT galaxy surveys.

5
Dr Stephen Ord
Research Fellow, Mar-11
Pulsars and the Variable Universe

I am project manager for the Variable Universe work package. I am also lead developer for the Murchison Wide-field Array correlator thats novel architecture employs FPGAs, GPUs and general purpose CPUs to perform the correlation task between all the elements of the array. I am also developing a high time resolution, data capture solution to enable observations of radio pulsars and rapid transient phenomena.

6
Samuel Oronsaye
PhD Candidate, Aug-12
Survey for Pulsars with the MWA

7
Dr Shantanu Padhi
Research Engineer, Jun-10
RF/Microwave, Antenna design, Electromagnetics

I am working on next generation sparse arrays system for aperture array radio telescopes as applicable to SKA-low framework.

8
Dr Sabyasachi Pal
Research Associate, Sep-09
Transients, multi-wavelength astronomy, micro quasars and radio astronomy

I do research to search for and understand transient sources in the sky.

9
Divya Palaniswamy
PhD Candidate, Aug-11
The High Time Resolution Dynamic Radio Sky

10
Dave Pallot
Data Archive Specialist, Jan-11
Software Engineering

I ensure the data is captured from the MWA and delivered into the hands of scientists. My time is split between software engineering tasks, network design and commissioning. My current focus is ensuring we deliver the full 128T system by June 2013.

11
Geoff Pocock
IP and Commercialisation Manager, Apr-10
Intellectual Property and Commercialisation

12
Dr Attila Popping
Super Science Fellow, Nov-10
HI observations

I am interested in doing observations and developing methods to detect very faint and deep emission of neutral hydrogen. My main role at ICRAR is to work on the science commissioning and preparation of DINGO, an ASKAP project to investigate very deep HI emission.

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1
Toby Potter
PhD Candidate, Sep-09
Radio Observations and Multi-dimensional Simulations of the Expanding Remnant of SN 1987A

2
A/Prof Chris Power
Research Associate Professor, Mar-11
Dark Matter and Galaxy Formation

I am a computational astrophysicist who works on dark matter and galaxy formation using supercomputer models. I model the role of supermassive black holes in galaxy formation, predict the neutral hydrogen properties of galaxies over cosmic time, and devise observational tests of the nature of dark matter.

3
Daniel Price
Research Associate, Nov-12
Radio Astronomy Instrumentation

I'm working on a new digital signal processor for 'The Dish', a 64m radio telescope in Parkes, NSW. This new system is called HIPSR, and it provides more processing power and better resilience to radio interference than the existing signal processor

4
Prof Peter Quinn
Director, Sep-09
Galaxy formation and evolution, interacting galaxies, computational cosmology, data intensive astronomy and operational systems for large megascience infrastructures

As Director of ICRAR I am responsible to the ICRAR Board, the Joint Venture partners (UWA and Curtin) and the WA State Government for the performance and operation of ICRAR and the delivery of its objectives according to the ICRAR Science and Technology Plan.

5
Hayden Rampadarath
PhD Candidate, Oct-10
Wide-Field VLBI & SETI

6
Taherah Rashnavadi
PhD Candidate, May-12
Engineering Development of Hardware Systems for High Time Resolution Radio Astronomy

7
Dr Cormac Reynolds
Senior Research Fellow, Sep-09
High Angular Resolution Radio Astronomy

I study Active Galactic Nuclei, principally by means of high angular resolution radio astronomy. I'm responsible for the installation and maintenance of our VLBI correlation facility.

8
Dr Maria Rioja
Research Fellow, Sep-09
VLBI technique, the use and development of new strategies

I work on the application of the VLBI technique to studies of AGNs, star formation regions and evolved stars, in a wide range of frequencies, to produce high precision astrometry and high resolution images. This enables proper motion, and distance-parallax measurements.

9
Dr Aaron Robotham
Research Assistant Professor, Oct-11
Extra galactic survey astronomy

I spend the majority of my research time working on the GAMA project, a large survey using telescopes from all around the world targeted on the same regions of sky. My particular focus is on collating and analysing galaxy redshift data that we obtain at the AAT in NSW.

10
Thomas Russell
PhD Candidate, Mar-12
The connection between inflow and outflow around accreting stellar mass black holes

11
Tina Sallis
Finance Officer, Jan-10
Finance

I'm responsible for monitoring and reporting on ICRAR finances at the Curtin node.

12
Dr Franz Schlagenhaufer
Research Engineer, Mar-10
Electromagnetic Compatibility (EMC)

I set up and operate an EMC lab for testing radio astronomy equipment for unintentional emission and also do RF survey measurements. There is also a research component to my work, in particular how to make emission measurements more sensitive by optimising a reverberation chamber.


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1
Morag Scrimgeour
PhD Candidate, Sep-09
Cosmology with Structure and Motion in the Universe

2
Dr Renu Sharma
Associate Director, Sep-09
Governance and Management

I am responsible for the planning, management, operations and efficient functioning of ICRAR. My aim is to support ICRAR to achieve international excellence and develop as one of the top most research and development organisations in astronomy science and engineering.

3
Dr Marcin Sokolowski
CAASTRO Postdoctoral Research Fellow, Jan-12
Data analysis and software development

I am currently working on the BIGHORNS experiment. The aim of the project is to observe a very weak signal emitted during the Epoch of Reionisation (EoR) when the first stars and galaxies were formed. After initial tests, we will deploy our system in the outback of WA in order to collect good quality data.

4
Dr Roberto Soria
Senior Research Fellow, Mar-11
Black hole accretion

I study how matter falls towards or into black holes and other compact objects. I find and monitor the activity of black holes in nearby galaxies, mostly by using X-ray data from space. I try to determine how much gravitational power is released via photons and how much in the form of kinetic energy of a jet, and how black hole power affects the surrounding matter.

5
A/Prof Christopher Springob
CAASTRO Research Assistant Professor, Sep-12
Galaxy Distances and Peculiar Velocities

I'm working on two different galaxy peculiar velocity surveys: The 2MASS Tully-Fisher Survey, and the 6dFGS Fundamental Plane survey. For both surveys, we use the motions of galaxies in the local Universe to derive cosmological parameters and test the lambda-CDM model.

6
Bruce Stansby
PhD Candidate, Sep-09
An Economical Survey Telescope to Study the Rate of Radio Astronomical Transient Events

7
Prof Lister Staveley-Smith
Deputy Director Science, Sep-09
The nearby Universe; neutral hydrogen in galaxies

I am a principal investigator of two key projects on ASKAP and MWA and am involved in several survey projects on Australian and international radio telescope facilities. Key goals in my research include understanding the evolution of stars and galaxies.

8
Roselina Stone
Administrative Assistant, Aug-12
Administration

9
Dr Adrian Sutinjo
Senior Research Fellow, Jan-12
RF engineering, antennas, electromagnetics

I work on low frequency antennas and arrays for next generation radio telescopes.

10
Jonathan Tickner
Senior Technical Officer, Mar-10
MWA Support and Lab Manager

I am a Safety and Health representative and assist in the physical fabrication of equipment used in ICRAR Activities.

11
Prof Steven Tingay
Deputy Director (MRO and Geraldton), Sep-09
Very Long Baseline Interferometry and technology for radio astronomy

I'm a Deputy Director of ICRAR and developed and lead several of the ICRAR projects. I contribute to these projects in terms of science and technical astronomy. I have particular interests in using commercial off-the-shelf technology for radio astronomy, a wide range of science, and outreach.

12
Michael Todd
PhD Candidate, Mar-10
Transient Astronomy using the 1.0-metre Zadko Telescope


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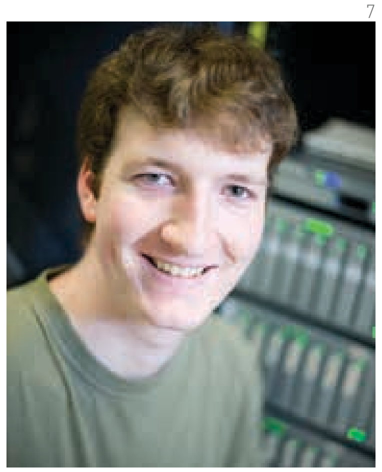
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1
Dr Steven Tremblay
CAASTRO Postdoctoral Research Fellow, Sep-11
High Time Resolution and Low Frequency Radio Astronomy

I am involved in several research projects here at ICRAR including using the MWA for high time resolution observations and the BIGHORNS experiment which is attempting to observe the global Epoch of Reionisation signature. I am also the CAASTRO Dynamic Universe Theme Scientist.

2
Dr Cathryn Trott
CAASTRO Postdoctoral Research Fellow, Apr-11
Signal processing theory; detection and estimation theory

I am involved in understanding the information limits of radio astronomy data, with application to designing and evaluating scientific metrics, and designing instruments. The science applications of my work are detection and classification of slow and fast radio transients, and estimation of the statistical signal from the Epoch of Reionisation.

3
A/Prof Kevin Vinsen
Research Associate Professor, Sep-09
Data Intensive Research, Machine Learning

I work in the Data Intensive Research Group addressing the issues caused by the huge data sets that modern radio and optical astronomy generates. My main research relates to developing methods for the automated classification of galaxies using multi-wavelength data and machine learning algorithms.

4
Dr Shane Walsh
Magellan Fellow, Aug-11

5
Jason Ruonan Wang
Masters Student, Jun-10
An MPI-OpenCL Based Radio Astronomy Software Correlator on Heterogeneous Clusters with Asynchronous Computing Topologies

6
Dr Bradley Warren
Research Assistant Professor, Sep-09
Interstellar Medium in Nearby Galaxies

I study the interstellar medium (atomic and molecular gas, dust) in galaxies close enough to resolve structure. I am particularly interested in gas dominated dwarf galaxies, where only a small portion of the atomic gas reserves have been converted to stars.

7
Mark Waterson
Senior Research Engineer, Nov-09
RF electronics design & testing

I lead the Radio Astronomy Engineering Lab, supporting design, construction & testing of the hardware used by ICRAR research projects. While focusing on low-frequency RF circuits we offer expertise across the range of modern electronics technologies.

8
Dr Randall Wayth
Postdoctoral Research Fellow, Sep-09
Radio Astronomy

I am the MWA Commissioning Scientist and the project manager for the Bighorns EoR Global Signal project. I'm leading the all-sky survey effort with the MWA during the commissioning period.

9
A/Prof Linqing Wen
Research Associate Professor, Sep-09
Gravitational Wave Astronomy

I am interested in gravitational wave astronomy especially in synergies of gravitational waves with electromagnetic radiation.

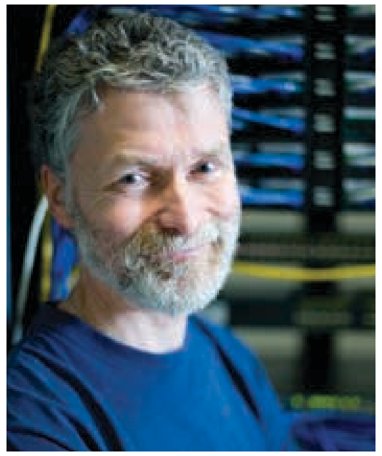
10
Stefan Westerlund
PhD Candidate, Mar-10
A Parallel Source Finder For Searching Radio Astronomy Images using High Performance Computing

11
Dr Tobias Westmeier
Research Assistant Professor, Oct-10
HI studies of galaxies; source finding and parameterisation

My research interests are related to the study of neutral hydrogen in and around nearby galaxies with the aim to study their structure and evolution. As a member of the WALLABY and DINGO projects I am working on the problems of source finding and source parametrisation in large, blind HI surveys.

12
Pete Wheeler
Manager, Outreach and Education, Sep-09
Science Communication

Our team provides an interface between ICRAR and the public. We coordinate ICRAR's online presence, interact with media, deliver events for schools and communities and work collaboratively with other groups to raise the profile of radio astronomy, science, ICRAR's work and the SKA.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Prof Andreas Wicenec

Professor of Data Intensive Research, Head of ICT Program, Aug-10

Data Flow Design and Optimisation

The ICRAR ICT team is working to support the ICRAR scientists in their endeavour to collect, archive and reduce the very large amounts of data produced by the latest instruments like MWA, ASKAP and in the future also the SKA. We are also deeply involved in the architecture and design of the SKA data system and its complex relations with the other SKA subsystems. In order to achieve this we have built up an extended network of collaborations with organisations and companies from around the globe. As part of our university responsibilities we are offering courses in HPC computing and are offering student internships, honours, masters and PhD projects.

2

A/Prof Chen Wu

Research Associate Professor, Mar-11

Data-intensive computing and service-oriented computing

My work involves developing data-intensive system technologies that integrate solutions from very large databases, distributed computing, and high performance storage to tackle the "big data" challenge in SKA precursor projects. I am currently working on data archive management and in-storage processing for the Murchison Widefield Array project.

3

Matthew Young

Astronomy and Astrophysics Course Coordinator, Sep-09

Education

I coordinate the Astronomy & Astrophysics university courses deployed by ICRAR in Western Australia. In particular I oversee the undergraduate courses at the University of Western Australia (UWA) and lecture at the third-year level on both Radiation Mechanisms and Compact Objects. I am also coordinating the replacement of the traditional one-year honours course by a two-year Master of Physical Science course that commences next year. More broadly I oversee the fourth-year courses delivered jointly to UWA and Curtin University students.

4

Cameron Yozin-Smith

PhD Candidate, Mar-12

CUDA-accelerated chemodynamical simulations of the Magellanic Clouds and other dwarf galaxies

5

Giovanna Zanardo

PhD Candidate, Sep-09

The Radio Evolution of SN1987A

ON THE HORIZON

1
The shape of the Milky Way resembles a giant emu according to the lore of the Indigenous group of the South-West, the Nyoongar people. Taken from Exmouth WA, this photo was the creation from a sudden bolt of inspiration. "Emu Crossing" received an Honourable Mention in the David Malin Awards, 2012. Credit: Richard Tonello, Astronomy Education Services

ON THE HORIZON

1
The Murchison Radio-astronomy Observatory (MRO) - the view towards the core site of CSIRO's Australian SKA Pathfinder radio telescope and MRO computing facility.

Through this continuing involvement in the evolving SKA facility, we can secure our long-term contribution to research and innovation in partnership with the WA, national and international communities.

The coming year will see the international SKA Organisation transition from being focused on the business of a site choice, to laying the foundations of the SKA design in preparation for the start of construction in 2016.

Under the guidance of Professor Phil Diamond, the new SKA Director General, and the newly established SKA Project Office in Manchester, the SKA project will embark on a four-year detailed requirements definition and design work program which will result in construction-ready specifications for SKA Phase 1. The work program will be executed across the SKA member countries via consortia of research organisations and industry, chosen competitively through a request for proposals process expected in the first quarter of 2013.

Member countries are expected to provide the approximately 90 million euros required for this work program and to support the central project office in Manchester. In Australia, the Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE) issued a call for expressions of interest in participating in the SKA pre-construction work program in October 2012. ICRAR used this opportunity to express its interest in contributing to the Aperture Array, Science Data Processor and Central Signal Processor parts of the work program. Based on the responses received, it is expected that DIISRTE will announce funding support levels for chosen Australian participants before the SKA request for proposals is released in early 2013. The unique experience ICRAR has received through the Murchison Widefield Array project and the priorities it placed on the development of human resources in science, engineering and ICT, has placed us in a strong position to contribute to, and potentially lead, significant parts of the SKA pre-construction program.

In addition to the pre-construction work, the SKA project will have to establish detailed agreements with Australia and South Africa on the preparation of the two sites and on the incorporation of existing investments into SKA Phase 1. The definition and execution of these agreements will require the establishment of an Australian SKA Project Office (ASPO) to act as the primary point of contact with the international project for developmental, planning and operational issues. The ASPO will coordinate Australian SKA activities on the site and between groups based in Sydney, Canberra, Perth and elsewhere.

Starting in 2013, ICRAR will work closely with the Director of the ASPO, and will provide facilities for ASPO staff at both ICRAR nodes. ICRAR will also continue its involvement with the Australian and New Zealand SKA Coordination Committee to support Australian input to the SKA Organisation board.

The initial funding for ICRAR from the WA State Government and Joint Venture partners will continue until July 2014. In order to ensure the critical mass of ICRAR staff in key science, engineering and ICT areas is maintained into the SKA pre-construction and construction eras, ICRAR is now pursuing a renewal of this funding until July 2019. ICRAR has submitted a proposal to the WA State Government for core staff funding in this period, and also to support ICRAR's participation in the response to the SKA request for proposals for the pre-construction work program. A response to the funding request is expected by early 2013. These new funds will allow ICRAR to continue to develop as a strong international research and innovation centre that participates fully in the SKA pre-construction period and engages the WA community and industry in the excitement and opportunities surrounding the SKA as it takes shape in the Murchison.

The period from late 2011 to the end of 2012 has seen significant milestones achieved by the international SKA community through creation of the SKA Organisation, the choice of a dual SKA site and the selection of the first SKA Director General. In the coming year the SKA will begin to finalise the design of an observatory that can potentially change the face of astronomy and physics. ICRAR is well placed to be a leading international organisation in this critical period for the definition of the scope, capabilities and detailed design of SKA Phase 1. Leaning on the skills and experience we have developed, and on our successful contribution to pre-construction, ICRAR can become a major player in the SKA construction and operations period. Through this continuing involvement in the evolving SKA facility, we can secure our long-term contribution to research and innovation in partnership with the WA, national and international communities.

ICRAR YEARBOOK

2011–2012

2011–2012