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CAASTRO acknowledges the support of the Australian Research Council and of NSW Trade and Investment. We also acknowledge the financial and in-kind support provided by our participating organisations – The University of Sydney, The University of Western Australia, The University of Melbourne, Swinburne University of Technology, the Australian National University, Curtin University and The University of Queensland.

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CAASTRO ANNUAL REPORT 2014

INTRODUCTION FROM THE CHAIR

DR ALAN FINKEL AM FTSE
CHAIR, CAASTRO ADVISORY BOARD

If science is a race and CAASTRO an entrant I am pleased to report that its competitive rate of laps is made possible by skilled drivers and a support crew that constantly monitors performance and tweaks parameters. A high volume of quality research is constantly underway and the KPIs are being met. The big change this year was the departure of the founding Director, Professor Bryan Gaensler, to head the Dunlop Institute at the University of Toronto. My colleagues on the Advisory Board join me in wishing Bryan much success in this new role and we are pleased to note that Bryan will continue his relationship with CAASTRO as a Partner Investigator. I already knew Bryan for several years before CAASTRO was conceived but it was only after the CAASTRO bid got underway that I became familiar with his prodigious capacity for multitasking and hard work that complements his academic expertise. Together, these skills enabled him to conceive of and build CAASTRO into a world-class organisation.

The heartbeat of the organisation hesitated when Bryan announced his intention to resign but I am pleased to report that it continues to beat strongly. Our current Director, Professor Elaine Sadler brings her own style and academic experience. Elaine is a high achiever in international astronomy and is well known inside CAASTRO as the head of the team studying extragalactic hydrogen absorption. Elaine has a superb research record in wide field astronomy combined with leadership experience that makes her eminently suited to lead CAASTRO across its range of activities.

CAASTRO was reviewed twice this year. The first was an internally initiated, mini science review undertaken by our own Advisory Board members Kenneth Freeman, Ron Ekers, Martha Haynes and Garth Illingworth. This was of enormous value because it led to acknowledgement of our strengths, areas that needed development and several opportunities. I thank Ken, Ron, Martha and Garth for their effort, which was enthusiastically offered by them and was above and beyond the call of duty.

The second was the Mid-Term Review by the ARC. The results from the ARC were very positive, and I can say that participating in the review reinforced for my colleagues and me the breadth of fronts across which the organisation is operating, while always maintaining efficiency and good humour.

Australia is well positioned in astronomy and has made major investments in telescope infrastructure, but the rest of the world is making even bigger investments. Nevertheless, we have our own competitive advantage in our instruments and our talent. That talent is publicly evident in the CAASTRO scientific staff, but is also abundantly evident in the A team of administrative staff that ensure that everything works all the time, with a minimum of fuss.

From my amateur perspective, astronomy is about to enter a golden age of telescope development with huge optical and radio telescopes coming on line that will deliver major increases in sensitivity and resolution. If I were to be reborn, one of the requests on my wish list would be to be an astronomer, ideally working at CAASTRO.

It’s not just about science. CAASTRO is actively committed to improving gender balance through providing a conducive workplace and promotional opportunities. We have an ever growing outreach program for schools and communities. And we provide mentoring programs and workshops for early career scientists in our organisation.

Finally, on behalf of all of us on the Advisory Board I offer my gratitude to those colleagues who retired during the year for various personal and work-related reasons. Alistar Robertson, Guy Robinson and Tanya Monro, you participated actively around the table and made a real difference. Our ongoing Board members (profiled elsewhere in this report) are fabulous contributors and I look forward to the participation of our incoming Board members Hugh Durrant-Whyte, Rachel Nowak, and Bronwyn Evans.

Astronomers look into the past. As Chair of the CAASTRO advisory board I’m in a position to look to the future. There is a lot to be done, and at CAASTRO we have the scientists and staff to do it well.
CAASTRO ANNUAL REPORT 2014

About CAASTRO

Astronomy is entering a golden age, in which we seek to understand the complete evolution of the Universe and its constituents. But the key unsolved questions in astronomy demand entirely new approaches, requiring enormous datasets covering the entire sky.

In recent years, Australia has invested more than $400 million both in innovative wide-field telescopes and in the powerful computers needed to process the resulting torrents of data. Using these new tools, Australia now has the chance to establish itself at the vanguard of the upcoming information revolution centred on all-sky astrophysics.

The ARC Centre of Excellence for All-sky Astrophysics (CAASTRO) has assembled the world-class team who now lead the flagship scientific experiments on these new wide-field facilities. CAASTRO is delivering transformational new science by bringing together unique expertise in radio astronomy, optical astronomy, theoretical astrophysics and computation, and by coupling all these capabilities to the powerful technology in which Australia has recently invested.

CAASTRO is pursuing three interlinked scientific programs, each of which can be addressed only with the all-sky perspective provided by wide-field telescopes:

- The Evolving Universe: When did the first galaxies form, and how have they evolved since?
- The Dynamic Universe: What is the high-energy physics that drives change in the Universe?
- The Dark Universe: What are the Dark Energy and Dark Matter that dominate the cosmos?

All CAASTRO activities are based on the principle that international leadership comes from commensurate investment in cutting-edge facilities and human capital. In particular, the CAASTRO research program is underpinned by a strong focus on training and enabling the next generation of scientists, thus providing a legacy extending well beyond the Centre’s lifetime. The students we mentor and inspire will lead the scientific discoveries made on future wide-field facilities, culminating in the ultimate all-sky telescope, the Square Kilometre Array. CAASTRO is further motivated by the belief that science is a passionate undertaking and this passion should be contagious. We aim to leverage the high impact and strong public interest in our discoveries to highlight Australian innovation to the general public, and to inspire students to consider careers in science and engineering.

CAASTRO is receiving more than $30 million in funding over the period 2011-2018. CAASTRO is led by The University of Sydney, in conjunction with The University of Western Australia, The University of Melbourne, Swinburne University of Technology, The Australian National University, Curtin University and The University of Queensland, complemented by a group of world-class Australian and international partners.

A Universal Perspective

A universal perspective of the cosmos, exploring the sky in its entirety not just section by section.

A universal perspective of science, engaging teams, scientists and the public in an inclusive and egalitarian way.

A universal perspective of insight and discovery, understanding how knowledge can be used practically in the wider world.
2014 has been a very successful year for CAASTRO, as well as a year of changes. CAASTRO’s founding Director, Professor Bryan Gaensler, announced in June 2014 that he would be stepping down before the end of the year to take up a new position as Director of the Dunlap Institute for Astronomy and Astrophysics at The University of Toronto. I took over from Bryan as CAASTRO Director on 15 September 2014, and I am enormously grateful to everyone who helped to make this transition a smooth one. I have been involved in CAASTRO since its inception, and I am delighted to have the chance to serve as the new CAASTRO Director. Bryan has left the Centre in fantastic shape, and will continue to be part of CAASTRO in his new role as an overseas Partner Investigator.

I hope you will enjoy reading about the great range of CAASTRO activities presented in this latest Annual Report. 2014 was another bumper year for our Centre, with new successes in our research and collaborative activities as well as our innovative outreach programs. Two of CAASTRO’s flagship facilities, the Murchison Widefield Array (MWA) radio telescope and the Sydney-AAO Multi-object Integral field spectrograph (SAMI) are now in full scientific operation and already producing some outstanding science results.

Our research highlights for 2014 include some notable firsts: the first real-time detection of a fast radio burst (by CAASTRO student Emily Petroff), the first public data release from the SAMI survey, and the first ASKAP detections of neutral hydrogen in the distant Universe. Our research publications continue to increase in number each year, and we are continuing to build new research links both within CAASTRO and more widely around Australia and across the world. All CAASTRO’s research themes and projects involve research collaborations across multiple nodes and institutions, and in 2014 we also held joint workshops with the ARC Centre of Excellence for Particle Physics at the Terascale (CePP) and training with the ARC Centre of Excellence for Ultrahigh bandwidth Devices for Optical Systems (CUDOS). This year we have developed new collaborations with the e-Science group at the Max Planck Institute in Germany and the US-led Large Synoptic Survey Telescope (LSST) project.

CAASTRO now has 178 members, including 28 postdoctoral research scientists and 40 students. Following our most recent hiring round, a number of new postdocs will also be joining us in 2015.

This year Tara Murphy joined the ranks of CAASTRO’s Chief Investigators, and we also welcomed Lisa Fogarty as the Theme Scientist for the Evolving Theme, Evan Keane as the Theme Scientist for the Dynamic Universe Theme and Michael Childress as the Theme Scientist for the Dark Theme. Our major research conference for 2014, ‘Supernovae in the Local Universe: Celebrating 10,000 Days of Supernova 1987A’, was attended by around 150 people, including many of the world’s leading experts in this research area.

Our education and outreach programs continue to thrive. This year saw the establishment of a new ‘Uluru Astronomer in Residence’ program in central Australia, in which CAASTRO scientists each spend two weeks interacting with visitors and conducting night-time sky viewing at the Voyages resort at Uluru. Our ‘CAASTRO in the Classroom’ program received a $195,000 grant from the Federal Government this year, which will allow us to extend these activities to many more schools across the country.

The 2014 CAASTRO Annual Retreat took place in relaxing surroundings at Twin Waters, Queensland, over 19–21 November, and was attended by almost 100 members of CAASTRO. As usual it was a great opportunity for all of us to meet and talk about our work. We enjoyed a stimulating program of science talks and networking activities, including invited talks from overseas visitors Professor Volker Springel (Heidelberg) and Dr Huib Intema (NRAO). The retreat also gave as an opportunity to farewell Bryan Gaensler in a formal way at our annual dinner, and to acknowledge his tremendous contributions to CAASTRO.

In November, we were delighted to hear that the 2015 Breakthrough Prize in Fundamental Physics had been awarded to CAASTRO Chief Investigator Brian Schmidt. The prize was also shared with CAASTRO Partner Investigators Warrick Couch and Reynald Pain, and Associate Investigators Brian Boyle and Chris Lidman. CAASTRO’s long-standing commitment to gender equity was recognised in December this year, when we were one of only two organisations awarded an inaugural 2014 Silver Readeas award from the Astronomical Society of Australia. The Readeas Awards recognise groups who take active steps to advance the careers of women in Australian astronomy and strive for sustained improvement in providing opportunities for women to achieve positions of seniority, influence and recognition.

The awards committee noted that: “We consider CAASTRO to be a leader in encouraging greater gender equity in astronomy in Australia, and many of the initiatives taken up by the project, such as encouraging flexible and part-time working, have been picked up by other astronomy groups.” This outstanding result is a tribute to the efforts of Bryan Gaensler, Kate Gunn and the CAASTRO Executive over the past three years, as well as the work of CAASTRO’s new Gender Action Committee, chaired by Brian Schmidt.

The last few months of 2014 also saw us busy with preparations for the ARC’s Mid-Term Review of CAASTRO, which took place in Sydney on 12 November. The feedback we received from the review panel was extremely positive, and the panel members were enthusiastic about all aspects of CAASTRO’s activities, including the excellent collaboration between nodes, the enthusiasm of our students and researchers, and the success of our mentoring and outreach program. They also commended CAASTRO’s gender equity activities, saying that our work in this area was a model for other organisations to emulate.

I am grateful to all those who came to Sydney for this review, and to Kate Gunn and our administration team for ensuring that the day ran like clockwork. Warmest thanks are also due to the CAASTRO Advisory Board members and Board Chair, Dr Alan Finkel, both for their valuable support in preparing for the review and for travelling to Sydney to meet with the review panel. The Mid-Term Review gave us an excellent opportunity to look back over the past three years and forward to the future. We were able to show that CAASTRO has robust governance and decision mechanisms that have allowed us to respond to external challenges, and that the CAASTRO ‘brand’ is internationally recognised and our scientific productivity is high.

Our goal now is to ensure that we translate the hard work of our first three years into ground-breaking science results. I hope that we can continue to strengthen the linkages between projects, increase our student numbers, and build new links with our international partners. We should all feel immensely proud of what CAASTRO has achieved so far, and excited by what is still to come.
When in the Universe’s history did the first galaxies form? How have gas, stars and galaxies subsequently evolved over cosmic time? These are two core questions in our understanding of the Universe, and the questions on which CAASTRO’s Evolving Universe theme is focused.

After years of planning and preparation, in 2014 we have seen major new Australian instruments start to produce exciting scientific results. Researchers using the Murchison Widefield Array (MWA) in Western Australia this year collected most of the data they will analyse in the search for the ‘Epoch of Reionisation’, the period in the Universe’s history when the first stars began to shine. BIGHORNS, a smaller project to search for the Epoch of Reionisation also led by CAASTRO researchers, was set up alongside the MWA this year. In addition, the MWA substantially completed a low-frequency survey of the southern sky, GLEAM, which will be a rich resource for many astrophysical studies. These three projects are described from page 10.

Searching for the Epoch of Reionisation

The earliest period of the Universe we can see is the cosmic microwave background: a hot, glowing screen of gas, which we see as it was some 380,000 years after the Big Bang. Between that time and the time of the earliest stars and galaxies is a gap of about half a billion years, a period dubbed ‘the Dark Ages’. This is the last major unstudied epoch of the Universe’s history.

In the period immediately after the Big Bang, the hydrogen gas that filled the Universe was hot and ionised, having had its electrons stripped off by the radiation that also filled the Universe. As the Universe expanded and cooled, this gas assumed its neutral, un-ionised state, and the Universe entered the Dark Ages. Towards the end of this period, collapsing matter formed the first entities that later generated ionising radiation (ultraviolet or X-rays); this radiation created bubbles of ionised hydrogen gas in the neutral hydrogen, like the bubbles in Swiss cheese. Carried to completion, the process led to today’s Universe, in which the gas between galaxies is fully ionised. Researchers wish to understand the astrophysics (and cosmology) underlying this Epoch of Reionisation (EOR).

When did the process take place, and how rapidly? How was matter distributed at this time? And, in particular, what were the first ‘ionisers’: were they the first stars, or black holes born from the violent collapse of those stars?

The ionising radiation from the first entities not only created bubbles of ionised hydrogen (HI) but also triggered the emission of specific radiation from the surrounding neutral hydrogen (HII): radio waves with a (rest-frame) wavelength of 21 centimetres. This HI emission is currently the only tool we have for exploring the Epoch of Reionisation. The future Square Kilometre Array radio telescope will directly image the distribution of the HI emission. Meanwhile, other attempts are being made to detect the EOR signal. The simplest detection would be of a ‘global’ signal, averaged over the whole sky: this would allow us to date the onset of the EOR and measure its duration. Researchers are also attempting to learn about the ‘bubbles’ of the EOR by measuring the HI power spectrum (the variation in signal strength by spatial scale). The shape of the power spectrum is predicted to change markedly as the ionisation of the intergalactic medium proceeds. This changing shape could indicate the nature of the first ‘ionisers’.

Attempts to detect the EOR signal face many challenges. During its long journey the signal is redshifted, arriving on Earth as low-frequency radiation that can be distorted by its passage through the Earth’s ionosphere. Even more significantly, the EOR signal is predicted to be extremely weak, and must be distinguished from far stronger foreground cosmic sources (both Galactic and extragalactic), man-made radio interference, and subtle effects generated by the observing instruments themselves. Researchers must understand well all these possible sources of contamination.
BIGHORNS

Theorists predict that the ‘global’ EOR signal will lie in the range 50–200 MHz and that its main features will appear around 70 and 100 MHz. In principle this signal could be detected by a single antenna. Several groups are planning or operating such experiments: one, led by CAASTRO researchers, a ‘BIGHORNS’ (Broadband Instrument for Global Hydrogen Reionisation Signal). BIGHORNS is distinguished by its bandwidth, 50–350 MHz, the broadest of any of the global EOR experiments, which will make it easier to distinguish the EOR signal from foreground or instrumental effects. BIGHORNS also has an unusual ‘backend’ processing system, which processes data with extremely high time resolution: in effect, it captures data continuously, making the system highly sensitive to weak signals. During 2012–2014 a preliminary version of BIGHORNS using an off-the-shelf antenna was deployed for short periods at three locations in Western Australia. In 2014 the BIGHORNS team replaced the system’s antenna with a custom-designed conical log-spiral antenna, better matched to the BIGHORNS receiver system, and made other improvements; in October the team installed the instrument at CSIRO’s Murchison Radio-astronomy Observatory (MRO), also in Western Australia, which is an extremely radio-quiet site. BIGHORNS new runs continue, collecting about 30 GB of data each day. As well as ‘listening’ for the EOR signal the instrument is also being used to measure the changes in the temperature of the electrons in the ionosphere and monitor both the Sun and any radio-frequency interference at the MRO. The BIGHORNS team will publish its initial science results in 2015.

The Murchison Widefield Array EOR experiment

While BIGHORNS is intended to detect the global EOR signal, the Murchison Widefield Array (MWA) was designed to detect the EOR power spectrum on the variation in signal strength by spatial scale. The MWA is a radio interferometer, a set of 2,048 antennas acting as one instrument; it operates at low frequencies (80–300 MHz). The compact antenna “tiles” (groups of 16 antennas) give it a very wide field of view, which makes it a superb survey instrument. The MWA is one of three official ‘precursor’ instruments for the future Square Kilometre Array telescope and is operated by an international partnership.

In its search for the EOR signal, the MWA will collect more than 1,000 hours of data; this volume is required to separate the weak EOR signal from contaminating signal from foreground galaxies (including our own) and noise in the data. Three fields are being observed: these are regions where the combined characteristics of sky and instrument are such that foreground contamination will be at a minimum.

Two main algorithms (‘pipelines’) have been developed to calibrate the data, and to two to measure the signal. One has been developed at CAASTRO nodes: the Universities of Melbourne and Sydney have developed one of the calibration pipelines, and Curtin University has developed one of the signal-processing (power spectrum) pipelines. The other two pipelines have been created by US partners in the EOR collaboration. Using multiple pipelines with different approaches provides a necessary cross-check on the data. In 2014 the MWA team produced trial power spectra from some of its collected data. As expected, most of the signal was due to contamination from foreground sources. CAASTRO researchers are devoting considerable effort to understanding the features of these sources, so that they may be removed from the data.

By the end of 2014 the MWA team had acquired 75 GB of data, a total volume of about 75 million years of computing time: most of the processing was done in 2015. These projects are described in the papers “BIGHORNS – Broadband Instrument for Global Hydrogen Reionisation Signal” (Publications of the Astronomical Society of Australia, February 2015) and “Science with the Murchison Widefield Array” (abst., April 2013).

GLEAM

As described on page 10, researchers using the Murchison Widefield Array are searching for the signal from the Epoch of Reionisation (EOR). To them, the foreground radio sources in our Galaxy and other galaxies are a nuisance to be removed from their data. But one researcher’s obstacle is another’s observable. In parallel with the EOR experiment, the MWA has been used to run a low-frequency survey of the entire southern radio sky: the GaLactic and Extragalactic All-sky MWA (GLEAM) survey.

GLEAM will be used to characterise foreground sources for both the MWA EOR experiment and low-frequency observations by the future Square Kilometre Array. But it provides much more than that. The detectability of radio sources depends on the frequency at which they are observed: sources detectable at high frequencies may not be so at low ones, and vice versa. GLEAM is the first survey of the southern sky at its frequency range, 73–230 MHz, and complements other southern surveys made at different wavelengths. It will also dovetail with a low-frequency radio survey of the northern sky, the Multifrequency Snapshot Sky Survey currently being made with the LOFAR telescope in Europe: together, GLEAM and MSSS will create an unprecedented low-frequency survey of the entire sky.

GLEAM will produce a rich dataset, useful for studying a myriad of subjects: radio galaxies and active galactic nuclei, galaxy clusters, the Magellanic Clouds (our nearest neighbours to our own Milky Way), diffuse Galactic emission, the Galaxy’s magnetic field, spectral line surveys of star-forming regions, pulsars and their wind nebulae, and cosmic rays. The MWA is extremely sensitive to large-scale structures such as radio relics and radio halos – arcs of radio-emitting charged particles that signpost where galaxies or clusters of galaxies have collided. Similarly, it is ideally suited to detecting older radio galaxies that are fading away after losing their central sources of power: these objects are invisible at high radio frequencies. Low-frequency observations give a true depiction of the power both the radio galaxies and high-frequency ones do. And they provide a means of observing young radio galaxies in the early distant Universe whose radio emission arrives on Earth significantly redshifted.

GLEAM began in 2013 and by the middle of 2015 will have gathered 814 hours of MWA data, a total volume of about 500,000 sources. The GLEAM extragalactic catalogue, which will be based on the first year of data, will be ready by 2015, and is expected to contain around 300,000 sources. The project is described in “GLEAM: the GaLactic and Extragalactic All-sky MWA survey” (Publications of the Astronomical Society of Australia, in press).

Extending the reach of HI surveys

Another major Australian radio telescope is coming to fruition in Western Australia: CSIRO’s Australian SKA Pathfinder. As the name indicates, this is one of the designated ‘pathfinder’ instruments for the future Square Kilometre Array. Like the MWA, is located at the Murchison Radio-astronomy Observatory; however, it operates at higher frequencies (700 MHz–1.8 GHz) and rather than dipole antennas it has dishes, each 12 m in diameter. In its first year, ASKAP will have a complement of 36 dishes: it is currently being commissioned with the first six, in a configuration called the Borelley Engineering Test Array (BETA). ASKAP is designed to be an extremely fast survey instrument, with a large field of view. During its first five years of operation most of its observing time will be used for ten large projects. Two of these, WALLABY and DINGO, will find galaxies through the radio waves emitted by the neutral hydrogen gas (HI) that they contain. A third, FLASH (the First Large Absorption Survey in HI), led by CAASTRO Director Professor Elaine Sadler, will seek to detect galaxies by looking for signs that they are absorbing HI emission from background sources. Two developments this year hold promise for these surveys. A ‘blind’ search for HI in absorption with the first six ASKAP antennas detected a signal: this is the first step towards FLASH. And a new way was found to use the data that WALLABY and DINGO will collect.

Venturing into the ‘HI desert’

Ten billion years ago galaxies were making stars ten times faster than they are today. To understand why, we need to understand the history of the gas, mainly hydrogen, that stars form from: how much there was, and where it was found, at different times in the Universe’s history. For six decades astronomers have mapped the distribution and movement of hydrogen gas in other galaxies by detecting the characteristic radio waves it produces, waves that are 21 cm long. But direct detection has only been possible for galaxies, because the signal of neutral hydrogen (HI) is relatively weak. Optical astronomers have a way to detect this gas in galaxies in the early Universe. But the two techniques still leave a gap of some seven billion years, half the Universe’s history, in which astronomers have struggled to detect HI. This ‘HI desert’ extends between redshifts of 0.3 and 2.0. Fortunately, HI can also reveal its presence by absorbing radio waves coming from a background galaxy. This manifests as a dip in the radio signal a telescope receives. By looking for absorption, astronomers can detect HI out to much greater distances than by looking for the emitted radiation. However, attempts to use this technique have been hindered by the limited bandwidth, frequency range and sensitivity of the radio telescopes available, and by man-made radio signals that can swamp the effects astronomers are trying to detect. As a result, most HI absorption surveys have been able to target only sources for which there is already information about the source’s distance (redshift); this tells astronomers which part of the radio spectrum the telescope should be tuned to.
Extending Tully-Fisher relations using HI stacking

The Tully-Fisher relation (TFR) is an empirical relationship between the mass of a spiral galaxy and its rotational velocity. In practice, luminosity is usually used as a proxy for mass. Astronomers use the TFR to calculate galaxy distances. But the TFR also shows something fundamental: namely, that at a given redshift, there is an essentially fixed ratio of dark to luminous matter in a spiral galaxy, regardless of its size. This means that studying how the TFR of galaxies changes over the Universe’s history gives us information about how those galaxies grow and change. To track this evolution, we need to measure the TFR at a range of redshifts.

A galaxy’s rotational velocity is most accurately measured using the 21-cm radio emission from the galaxy’s neutral hydrogen gas (HI): the width of the HI line profile gives the rotational velocity. But the HI signal is weak, so TFR studies have been limited to relatively nearby galaxies.

CAASTRO PhD student Scott Meyer (University of Western Australia) and his colleagues have now found a way to extend the TFR to higher redshifts. They used stacking, a process of combining the weak signals of many individual galaxies, mostly in the fields covered by the multi-wavelength Galaxy And Mass Assembly (GAMA) project. The survey has been awarded 150 observing nights over three years. Ninety nights had been completed by the end of 2014. The key science goals of the SAMI Survey are to determine the role of the environment in shaping the TFR; and to establish a new scaling relationship between the growth of stellar mass and changes in angular momentum in galaxies; and to investigate the flow of gas in and out of galaxies, and the effect of these flows on star formation.

Data, and publications derived from them, began to emerge this year. The SAMI team presented its Early Data Release for the general astronomical community in July: this comprised fully calibrated datacubes for a selection of 107 galaxies that represented the full spectrum of galaxy types. The data-release paper also demonstrated the SAMI data-processing pipeline’s high level of performance.

Science results from SAMI published this year were:

- a study of the relationship between the kinematic morphology-density relation in 114 field galaxies (MNRAS, 2014); and
- a study of the use of the TFR to determine the age and rotational velocity of spiral galaxies (ibid., December 2014).

The follow-up of the TFR at high redshifts is now underway, using SAMI and its pointed mode. SAMI is expected to detect a large number of galaxies at redshifts in excess of 0.4, and the survey is expected to cover a wide range of galaxy types, from galaxy clusters to low-mass dwarf galaxies. The TFR measurements at high redshifts will provide important insights into the evolution of galaxy formation and structure, and will help us to understand the processes that shaped the Universe.

The first science from SAMI

Galaxy evolution is complex: gas, stars, dust, supernovae and super-massive black holes all play a part.

Over the last 15 years much has been learned about the process of star formation in galaxies. Many galaxies have been found to have a high level of activity, with the formation of new stars and the injection of energy from supernovae and super-massive black holes. The study of these processes is key to understanding the evolution of galaxies and the formation of new stars.

The TFR is a fundamental tool for estimating galaxy distances, and it is also a key tool for understanding the role of the environment in shaping the properties of galaxies. The TFR is based on a simple assumption: that the mass of a galaxy is proportional to its rotation velocity. This assumption is known to be incorrect, and it is not clear how well it applies to galaxies at high redshifts.

The SAMI Galaxy Survey is expected to provide new insights into the TFR at high redshifts, and to help us to understand the processes that shaped the Universe.
For millennia people thought of the heavens as largely unchanging, the realm of the fixed, eternal stars. But we now know the Universe to be extraordinarily dynamic and violent, with change taking place not just over millions or billions of years but also within days, hours, seconds, and even fractions of a second.

The Dynamic Universe theme focuses on all-sky surveys for variable and transient objects. In particular, we are making radio observations with the Murchison Widefield Array, CSIRO’s Parkes radio telescope and the University of Sydney’s upgraded Molonglo Observatory Synthesis Telescope. With their wide fields of view, frequency ranges and time resolution, these surveys are allowing us to reach into new ‘discovery space’. One such survey, begun this year, is SUPERB (the Survey of UltraFast Radio Bursts). The kilome- tre Array and the Large Synoptic Survey Telescope will generate vast volumes of data to be explored the use of automated classifiers for dealing with voluminous data, one dealing with variable sources (described on page 16) and one with pulsars (page 16).

SUPERB: a survey for fast radio bursts

‘Fast radio bursts’ (FRBs) are fleeting cosmic radio signals, lasting just a few milliseconds. The first FRB was discovered in 2007; to date, seven have been discovered in archival data taken with CSIRO’s Parkes radio telescope, and an eighth in the archive of the Arecibo telescope in Puerto Rico. One further burst was discovered in ‘real time’ with Parkes in 2014 by CAASTRO student Emily Petroff; this work is described on page 32.

The bursts are strong for cosmic radio signals, around a janskys (the radio astronomers’ standard unit for flux measurement). All of them show a large frequency-dependent time delay (‘dispersion measure’), caused by free electrons in interstellar and intergalactic space, meaning that they must have originated billions of light-years away. For the bursts to be so strong even when coming from such distances, their sources must emit in a few milliseconds enormous amounts of energy. New ways of combining characteristics could make them important tools for probing the cosmos. They could, for instance, locate the ‘missing cosmic baryons’: matter, so far undetected, that may lie in the outermost regions of galaxies or in intergalactic space. Unlike any other observational technique, the dispersion measure of an FRB is sensitive to the number of free electrons along the line of sight. Finding around a hundred FRBs would give us useful information about the baryonic mass of the Universe. By contrast, just a single FRB might allow us to measure the magnetic field in the space between galaxies: if it were linearly polarised, the magnetic fields in space would change the direction of this polarisation by a measurable way.

With many such FRBs, lying in different directions, we could map the magnetic field of intergalactic space.

But above all, astronomers wish to determine the phenomenon that generates the FRBs. This will require the FRBs to be detected in real time, so that rapid follow-up observations can be made at many wavelengths, by several telescopes. A survey to do just that began on CSIRO’s Parkes radio telescope this year: SUPERB, the Survey for Pulsars and Extragalactic Radio Bursts, led by Evan Keane (Swinburne University), Theme Scientist for CAASTRO’s Dynamic theme. As its name indicates, SUPERB is a ‘real-time’ survey for pulsars as well as for fast radio bursts; although the scientific goals for detecting pulsars differ from those of FRBs, both can be accomplished in the one survey.

SUPERB extends the successful HTRU ‘High Time Resolution Universe’ survey carried out at Parkes since 2008. It targets Galactic latitudes langes up and down from the Galactic plane in which previous FRBs have been found, and uses the SPINN neural network (described on page 16) and other data-processing techniques that allow pulsars and FRBs to be identified in real time and followed up immediately. Importantly for FRB studies, SUPERB captures the polarization information of signals it detects. Ten other telescopes, working at wavelengths from radio to X-rays, are poised to respond to a detection by SUPERB on Parkes; data from the gravitational wave experiment LIGO will also be searched for traces of the FRB after the exact time the burst occurred is pinpointed.

SUPERB is expected to discover approximately 20 of the super-fast millisecond pulsars and about 100 ‘normal’ ones. By the end of the survey, the team had detected a ‘millisecond’ pulsar with a period of 6.38 milliseconds, and two slower ones—one that scintillates strongly and a second that turns its pulses ‘on’ and ‘off’ every few minutes. SUPERB is intended to take 1000 hours of data, and will run until 2016.

Text results from the Random Forest classifier. The colour bar represents the true positive rate. The overall accuracy is 97%. Credit: Kitty Lo (University of Sydney)

An automated classification system for X-ray sources

Future telescopes such as the Large Synoptic Survey Telescope and the Square Kilometre Array will generate terabytes of sky-survey data each day. Buried within that data will be transient signals from gamma-ray bursts, gravitational wave sources, coalescing neutron stars, exoplanets—and from totally new, unexpected phenomena. Identifying such signals will be beyond the capacity of human observers: automatic classification is required. One of the most accurate classification algorithms, Random Forest, has already been used successfully with variable stars and supernovae. In 2014 CAASTRO PhD student Kitty Lo and her colleagues assessed its performance in classifying variable and transient X-ray sources.

‘A random forest’ is an ensemble of decision trees, all different. Each tree is presented with an unclassified object; the tree allocates it to a class, effectively ‘voting’ for it; and the most common vote from the forest is the classification. The algorithm’s probability of the classification being correct is the fraction of ‘votes’ cast for that class.

The decision trees are built from a set of training data and set of relevant features (for instance, luminosity). To build one, objects are chosen at random from the training set. Then for each node (decision point) on the tree, the algorithm randomly picks a subset of features and selects the best for splitting the tree into branches, the ‘best’ being the one that most reduces the chance of the item being incorrectly classified. Each object presented to the tree passes through a series of nodes until it is given a final classification and arrives in a ‘leaf’ on the tree.

Finding rare and novel objects is an important goal for future transient surveys. A Random Forest classifier cannot correctly label sources of a kind that it has not been trained on; it can reveal novel sources. They show up widely separated on the ‘leaves’ of the tree from other objects of the same class: that is, they are outliers.

To train and test their Random Forest classifier, Lo and her colleagues used 873 sources from the X-ray Multi Mirror Mission – Newton (XMM-Newton), sources whose classification was already known. They evaluated the classifier’s accuracy using ‘10-fold cross-validation’, alternatively training and testing on subsets of the training set.

In their first round of tests, Lo et al. used only time-series features, such as the duration of the strongest flare—27 features in all. With these, the classifier was able to correctly identify 77 per cent of sources, which is not enough to be practical. But adding a further 22 ‘contextual’ features, such as proximity to galaxies and cross-matches with sources at other wavelengths, boosted the accuracy to 97 per cent. Lo and her colleagues concluded that, to perform well, classifiers hunting for variables and transients will need more to work with than just temporal flux measurements.


CSIRO’s Parkes radio telescope, which is being used for the SUPERB survey. Credit: CSIRO
Pulsar identification using neural networks

Like the transient and variable sources discussed on the previous page, the compact, rapidly rotating stars called pulsars are relatively rare objects, and notoriously difficult to discover. Nevertheless, modern searches for pulsars generate millions of pulsar candidates, most of which are not pulsars, but ‘noise’ or radio-frequency interference. Each candidate must be inspected by an astronomer to determine if it is indeed likely to be a pulsar, and re-observed: only then can it be confirmed as a pulsar. Future surveys will present an even greater challenge: the Square Kilometre Array telescope is expected to find 20,000 pulsars, but only after 200 million candidates have been correctly classified.

So, like astronomers searching for transients, pulsar astronomers are turning to automated classification.

Pulsars are distinguished by their regularly pulsed signals, and searching for them requires large-scale data mining. Once a potential signal is identified, the data can be ‘folded’ (coherently stacked) to reveal the pulse profile of a potential pulsar—a candidate.

Each candidate has a set of diagnostic information or features, such as the signal-to-noise ratio of the pulse profile. A few attempts have been made to classify pulsar candidates automatically. CAASTRO PhD student Vincent Morello (Swinburne University) has used a straightforward pulsar identification using neural Networks. As its name indicates, SPINN (Straightforward Pulsar Identification using Neural Networks) is a network of computational models called artificial neurons. Morello and his colleagues trained and tested SPINN on data from the southern High Time Resolution Universe (HTRU) survey, carried out with CSIRO’s Parkes radio telescope. The training set contained 90,000 non-pulsar candidates chosen at random, and 542 confirmed pulsars found in HTRU data that had been re-processed with a new pulsar-searching pipeline, PEASOUP.

Following training, SPINN was used to classify all 4.36 million pulsar candidates generated by PEASOUP. This process took only 400 CPU hours, and could be accomplished overnight on Swinburne University’s gSTAR cluster.

The goal of an automated classifier is to maximise ‘recall’ (that is, the fraction of pulsars labelled as such) while minimising “false positives” (noise or RFI mislabelled as pulsars). SPINN can be tuned to optimise one of these factors or the other. At 70% recall, its false-positive rate was 0.64%; at 90% recall, it was 0.01%. While SPINN is successful in finding new pulsars, its false-positive rate is still two orders of magnitude higher than that of an experienced pulsar astronomer. However, SPINN can reduce the number of candidates that have to be inspected by eye, by up to four orders of magnitude. Overall, SPINN is a significant improvement on previous classifiers.

The performance of automated classifiers depends strongly on the properties of the data they are trained on and evaluated with. Morello et al. have made publicly available the dataset they used for this project, so that other classifiers—perhaps including ones generated outside astronomy—can be compared with SPINN. As yet, none has bettered SPINN’s performance.

The work was described in “SPINN: a straightforward machine learning solution to the pulsar candidate selection problem”, published in Monthly Notices of the Royal Astronomical Society in September 2014.

Searching for exoplanets with the MWA

In 1995 astronomers found the first planet outside our solar system that orbited a Sun-like star. Today there are more than 1,000 exoplanets known, with a further 3,000 or so candidate systems waiting confirmation. Almost all have been discovered indirectly, most often through effects a planet can have on the light of its parent star. Only a few exoplanets have been found by direct imaging at optical or infrared wavelengths.

But direct radio detection may also be possible. Large, Jupiter-like planets with strong magnetic fields (and a source of energetic electrons) should emit low-frequency radio waves, as Jupiter does. While at optical wavelengths the parent star can be a million times brighter than its planets, at radio wavelengths the two can be of comparable strength.

Radio searches for exoplanets are part of the program for the low-frequency component of the forthcoming Square Kilometre Array radio telescope. To verify the validity of the approach, CAASTRO Chief Investigator Tara Murphy (University of Sydney) and colleagues have begun a systematic search for exoplanetary emission with the Murchison Widefield Array (MWA), which operates at 80–300 MHz. This search is a component of the larger MWA Transients Survey (MWATS), which will cover the southern sky at 154 MHz, looking for radio sources that vary over months, hours and minutes.

Of the 1,110 exoplanetary systems confirmed at the time this work began, 34% fall within the region that MWATS had covered by mid 2014. Murphy and her colleagues calculated the expected maximum emission frequency and flux density for these sources, and selected those for which these parameters were close to or above the MWA’s detection capabilities. They also included ten sources that had been identified as the most likely candidates for radio emission generated by magnetosphere–ionosphere coupling. This resulted in a sample of 17 candidates, 13 of which had not previously been observed at radio wavelengths.

Murphy and her colleagues detected no radio emission from a band of radio emission at a centre frequency of 154 MHz, and put 3σ upper limits in the range 11.2–112.5 mJy. They also searched for circularly polarized emission and made no detections, obtaining 3σ upper limits in the range 3.4–49.3 mJy. These limits are comparable with the best limits from other low-frequency surveys. If the emission is assumed to be completely circularly polarized, they translate to luminosity limits of between 1.2 × 10^14 and 1.4 × 10^15 W—at least three orders of magnitude greater than the luminosity of Jupiter.

Why was no emission detected? There are a few possible reasons. More sensitive observations may be needed. The observing frequency, while lower than that of previous studies, was still higher than the predicted maximum emission frequency for many systems in the sample. And radio emission from exoplanetary systems is likely to be ‘beamed’ in the plane of the planet’s orbit, and also sporadic. Future work with the MWA will use lower-frequency (90 MHz) observations and cover the full orbital period of several known systems to increase the probability of detection.

The paper describing this work, “Limits on low-frequency radio emission from southern exoplanets with the Murchison Widefield Array”, was published online by Monthly Notices of the Royal Astronomical Society in November 2014.
Our current ‘standard model’ of the Universe, which is our best description of how it works, is a model that contains dark energy (designated by the Greek letter \( \Lambda \), Lambda) and cold dark matter. It is therefore known as the \( \Lambda \)CDM (Lambda cold dark matter) model. This model accounts well for our observations of the cosmic microwave background; the large-scale structure of the Universe how galaxies are distributed on large scales); how much hydrogen, helium and lithium the Universe contains; and the accelerating expansion of the Universe, discovered in the late 1990s, which is attributed to ‘dark energy’. The \( \Lambda \)CDM model also assumes that general relativity is the correct theory of gravity governing the cosmos.

However, the dark-energy term, \( \Lambda \), is open to question. Lambda is the ‘cosmological constant’ that Einstein inserted into his equations for general relativity. It is by no means established that dark energy is of this nature: there are other candidates, and they would produce observable differences from the cosmological constant. It is also possible that, on the large scales, gravity is better described by a theory other than general relativity. Much of the work in CAASTRO’s Dark Universe theme in 2014 has involved testing these possibilities.

This year, a CAASTRO-led team released the final sample of the ‘peculiar velocities’ of galaxies (galaxy movements resulting from gravitational attraction) from the 6dF Galaxy Survey. This is the largest such survey ever made; large enough to allow researchers to check if the local Universe is consistent with \( \Lambda \)CDM. CAASTRO researchers used the dataset to make two such consistency tests, by calculating the ‘bulk flow’ of the local Universe and, for the first time, measuring the rate of growth of structure on scales larger than 300 million light-years. (These projects are described later.) The peculiar velocity data was also used to test for one of the modified versions of general relativity (page 20). While some CAASTRO researchers were using peculiar velocities as tools, others were correcting for their effects in the data from the WiggleZ galaxy survey, allowing them to make a more precise determination of the ‘baryonic acoustic feature’ (a measure of galaxy clustering) and from that, a value for the parameter \( w \), which describes how dark energy reacts to the expanding universe. This work is discussed on page 21.

The effects of dark energy is the aim of another long-term project, the Dark Energy Survey (DES). A number of CAASTRO researchers are contributing to this through OzDES, an Australian observing program that aims to measure for DES the redshifts of around 3,000 Type Ia supernovae. OzDES began in 2013 and by the end of 2014 had completed its second season of observing; its progress is discussed on page 22. Meanwhile, other CAASTRO researchers have had a look ‘under the bonnet’ of Type Ia supernovae, the ‘standard candles’ on which many dark-energy studies rely. These findings are discussed on page 23.

Cosmological tests with peculiar velocities

In general, galaxies ‘go with the flow’: they move further apart as the Universe expands. But this is not the whole story. Galaxies are also drawn together by their mutual gravitational attraction. And this gives them an additional component of motion: their ‘peculiar velocities’. By measuring the speed and direction of these individual movements, researchers can map the gravitational forces that are tugging on the galaxies, and so determine how matter, seen and unseen, is distributed.

This year, CAASTRO Research Staff member Christopher Springob (University of Western Australia) and colleagues have publicly released data on the movements of 8,888 galaxies, almost double the number measured by the largest previous study of this type. This new set of peculiar velocities was derived from the 6-degree Field Galaxy Survey (6dFGS), which was carried out with the 1.2-m UK Schmidt Telescope at Siding Spring Observatory in northwest NSW. The survey recorded redshifts for more than 110,000 galaxies over 80 per cent of the Southern sky. The galaxies in the peculiar-velocities sample are spread over a region 1.5 billion light-years across, the largest volume ever covered by such a survey. The size of this survey will enable researchers to test for the first time if our local region is representative of the Universe as a whole, and whether our standard cosmological model, \( \Lambda \)CDM, correctly predicts galaxy movements.

A number of peculiar-velocity surveys carried out in recent years suggested that the ‘bulk flow’ of galaxies in the nearby Universe (their movement en masse under the influence of gravity) was not consistent with the predictions of the \( \Lambda \)CDM model (in fact, faster). But yet other studies suggested that it was. CAASTRO PhD students Morgan Scrimgeour and Christina Magnelli are contributing to the debate, using the 6dFGS peculiar velocities to calculate the bulk flow of local galaxies. They used different methods, but both found the bulk flow to be consistent with the \( \Lambda \)CDM model, although greater than one would expect from the large-scale structure we observe in the nearby Universe.

Christopher Springob (Swinburne University) and his colleagues have used the 6dFGS peculiar velocities to carry out another kind of test, a test of our model of gravity. The cosmic microwave background reveals very slight fluctuations in the density of matter in the Universe. Over time, the slightly denser regions accumulated more and more matter, leading to the large-scale distribution of galaxies that we see today. General relativity predicts that the rate at which this large-scale structure has grown depends only on time. But some other theories of gravity predict that the rate of growth differs on different spatial scales. Of the various techniques that can be used to constrain theories of gravity in this way, peculiar velocities are uniquely able to probe the growth rate of structure on scales greater than 300 million light-years.

Johnson et al. have made the first test of the growth of structure on this scale, using the peculiar velocities from 6dFGS and a sample of low-redshift (z < 0.07) Type Ia supernovae (another means of tracing the peculiar velocities of galaxies). They found that the growth of structure is consistent with the standard model’s prediction (although slightly higher than expected), with no evidence for scale-dependence in the growth rate. The growth rate they calculated was also consistent with one previously derived from redshifts from the 6dFGS sample by Bouwert et al. (2012).

Two future Australian peculiar-velocity surveys, TAPAN (to be carried out on the 1.2-m UK Schmidt Telescope) and WALLABY (to be done with the 64-m Australian Square Kilometre Array Pathfinder radio telescope), will measure the rate of growth of structure even more precisely, to within three per cent (at \( z = 0.025 \)). Both will involve many members of CAASTRO.

The peculiar-velocities work described here was reported in “The 6dF Galaxy Survey: peculiar velocity field and cosmography” (Monthly Notices of the Royal Astronomical Society, December 2014) and “The 6dF Galaxy Survey: cosmological constraints from the velocity power spectrum” (ibid., November 2014). As of the end of 2014, the work of Scrimgeour was under review.
Testing a modified theory of gravity

As mentioned on page 18, our current standard model of the Universe, the ΛCDM model, posits the existence of both dark matter and dark energy. In fact, the existence of both is driven by the fact that the dark energy is the negative pressure that drives the accelerated expansion of the Universe. This is one way to determine the parameter $\Lambda$, which characterizes the energy density of the dark energy. As the two are thought to have different production mechanisms, this also is surprising. Several kinds of observations have suggested that dark matter does not behave as predicted (although some of these discrepancies may be resolvable). All this may signal that we need to go beyond general relativity in describing gravity.

Extending general relativity began as early as 1918, and there are now many ‘modified’ theories of gravity. As a group, they differ from general relativity in their predictions for how matter will cluster and grow into large-scale structures. The predictions also differ from model to model. Growth-of-structure observations can therefore be used as a discriminator.

This year, CAASTRO Associate Investigator David Parkinson and his colleagues have tested f(R) models of gravity: extensions of general relativity that include a scalaron, a scalar field not present in general relativity, which is a candidate for dark energy. The mass of this field depends on the local matter density (it will be high where the local matter density is high, for instance). The mass of the scalaron in the local Universe is represented by a parameter $B_0$. Parkinson and his colleagues looked for evidence of a non-zero value of $B_0$.

Previous work had placed upper bounds on $B_0$. Observations of the cosmic microwave background with the Planck satellite had given $B_0 < 0.1$. Combining tracers of large-scale structure with data from the WMAP (Wilkinson Microwave Anisotropy Probe) satellite had given an even more stringent constraint, of $1.1 \times 10^{-3}$ (both figures are at the 95% confidence limit). By adding WiggleZ observations to the Planck data, Parkinson’s team improved the previous best limit for $B_0$ by another order of magnitude, to $\log_{10}(B_0) < -4.07$ ($= 8.5 \times 10^{-5}$). This represents one of the tightest constraints on $B_0$, and thus on f(R) models, to date.

This work was described in the paper “Constraining models of f(R) gravity with Planck and WiggleZ power spectrum data”, published in the *Journal of Cosmology and Astroparticle Physics* in March 2014.

Sharpening the WiggleZ

One way to investigate the nature of dark energy relies on detecting a pattern in how galaxies are distributed in space. Pairs of galaxies have a slight ‘preference’ for being a certain distance apart. When measured in space, this distance is 490 million light-years. Where does this pattern come from? It was created by pressure waves (sound waves) that existed in the Universe when it was very young, no more than a few hundred thousand years old, and very hot. As the Universe cooled, the sound waves became ‘frozen’ and the signature of the ‘preferred spacing’ is still seen in the distribution of matter; it is known as the ‘baryon acoustic feature’.

As the Universe has expanded over its lifetime, the galaxy clustering pattern has changed accordingly. Measuring the preferred distance of galaxies at several stages of the Universe’s history is a way to track the rate of expansion of the Universe and how that has changed over time. Importantly, this method is completely independent of the measurements of the expansion made using Type Ia supernovae (such as the OeDES project, described on page 22, will contribute to). Measuring the galaxy-clustering pattern is one way to determine the parameter $\omega$, which characterizes dark energy. If $\omega$ can be measured with sufficient certainty, it will rule out some candidates for dark energy.

Several projects have been carried out to measure the preferred spacing of galaxies. The first one to produce significant results for high redshifts (that is, for much higher redshifts) was WiggleZ, a survey we carried out with the 4-m Anglo-Australian Telescope. The WiggleZ team measured the preferred spacing of galaxies when the Universe was about 8 billion years old (corresponding to a redshift of 0.6), and published its results in 2011.

However, the signature of the ‘preferred spacing’ is not sharp. As discussed on page 19, galaxies aren’t just carried along by the expansion of the Universe, but also have their own, ‘peculiar’, velocities, that arise from gravitational attraction. In fact today the galaxies are displaced, on average, by some 16 million light-years from where they’d be if they weren’t influenced by gravity. The effect is to ‘blur’ the spacing of the preferred separation. It’s like looking at a car’s headlights at night: if the night is clear, the spacing between them is easily seen, but if the night is foggy, the spacing is harder to measure.

This effect has been understood for a long time, and in 2007 Eisenstein et al. suggested a way to correct for it: use the density field (that is, a map of gravitational potential) to work out how much the galaxies have been displaced in effect, put them back in their original positions; and then re-calculate their preferred spacing. The technique has been successfully applied to galaxy samples obtained by the Sloan Digital Sky Survey. But it was not clear if it would work for WiggleZ, which had been carried out over several non-contiguous volumes, meaning that there are ‘edge effects’; also, the WiggleZ data was patchy in some areas and inherently sparse at higher redshifts.

To learn if ‘reconstruction’ could be usefully applied to the WiggleZ data, CAASTRO Research Associates Eyal Kazin and Jun Koda (Swinburne University) and their colleagues created 600 simulated catalogues of galaxies and tested the procedure on those. In two-thirds of the cases this yielded a better-defined baryonic acoustic feature. When applied to the WiggleZ data itself, the technique decreased the uncertainties of the measurement from 4.5–7.5% (the figures vary by redshift) to 3.4–4.8%. This is a significant improvement, effectively equivalent to the result expected from a survey with up to 2.5 times the volume of WiggleZ.

Combining their new measurement with others from the Six-Degree Field Galaxy Survey (6dFGS) and observations of the cosmic microwave background, the researchers calculated a value for $\omega = -1.08 \pm 0.14$, which agrees well with others in the literature reached through different techniques, and also with the standard ‘flat’ ΛCDM cosmological model that predicts $\omega = -1$. Their calculated values for other cosmological parameters were, reassuringly, also in line with the standard ‘flat’ ΛCDM cosmological model.

OzDES and the Dark Energy Survey

Is dark energy the ‘cosmological constant’ that Einstein built into his general theory of relativity, or a sign that that theory is incomplete? One of the largest attempts so far to answer that question is the Dark Energy Survey (DES), a 5-year international project led from the USA and UK.

DES is measuring the effects of dark energy in four ways. One of them involves determining the brightness of Type Ia supernovae. This was the technique that originally uncovered dark energy: DES aims to improve its precision by finding thousands of new supernovae between redshifts of 0.2 and 1.2. To this end, a 570-megapixel ‘dark energy camera’, DECam, is now surveying the southern sky from the Chilean Andes.

Having found the supernovae, DES needs their redshifts. These were traditionally obtained once supernova at a time, by taking a spectrum of each exploded star before its light had faded. But with so many supernovae being found, it’s impractical to follow each one up while it is still bright. In most cases, therefore, the strategy is to obtain a redshift for the supernova’s host galaxy, which can be done at leisure.

The 2dF instrument on the 4-m Anglo-Australian Telescope (AAT) in eastern Australia has a field of view vastly the same as that of DECam, and the combination of 2dF (which positions optical fibres for capturing light) and the AAOmega spectrograph (which analyses the light) allows almost 400 redshifts to be measured simultaneously. Using these instruments, OzDES, the Australian Dark Energy Survey to measure redshifts for DES; began in 2013. OzDES involves 10 Australian institutions and 30 Australian researchers, including many affiliated with CAASTRO; CAASTRO also provides postdoctoral support for the project. The survey has received an allocation of 100 nights on the AAT, spread over five years.

By the end of 2014, OzDES had completed its second season of observing, 26 nights in total. It has obtained redshifts for 11,000 targets, of which 1,200 are the host galaxies of transients, mostly supernovae. Of these galaxies, about 240 have been confirmed as the hosts of Type Ia supernovae that will be useful for cosmological studies. OzDES is well on the way to meeting its target of about 3,000 such redshifts after five years of observing.

The first scientific papers from OzDES will be published in the first half of 2015.
When new techniques are created for acquiring or processing medical images, they have one goal: to improve image quality. That is, to make it easier for a radiologist to spot what he or she is looking for, a tumour, for instance.

The ultimate arbiter of image quality is the trained radiologist. But this means that new imaging techniques have to be assessed by trained radiologists, and that is a lengthy (and expensive) process.

To carry out such tests on new techniques, it is useful to have reliable mathematical algorithms that can mimic the lesion-detecting skills of a trained person. Algorithms have been developed for this purpose, but they still fall short of human abilities. Source recognition is a major issue in astronomy too. The human eye and brain are excellent at pattern recognition and, therefore, in finding sources in data. But the volume of data from telescopes such the future Square Kilometre Array and its precursors, such as the MWA and ASKAP, makes automated source recognition a must.

CAASTRO Affiliate Cathryn Trott (Curtin University) is a specialist in extracting information from astronomical data. Like medical images, astronomical images are filled with extraneous signals and noise, and detecting an object within these complex datasets requires optimal methods. In an interdisciplinary project, Trott worked this year with the Positron Emission Tomography (PET) Imaging Physics team at Massachusetts General Hospital in Boston, USA, to design a new algorithm that more closely mimics a trained radiologist.

PET imaging is used extensively to measure glucose use in the body, and is a principal tool used by oncologists to detect cancerous tumours. Detecting a tumour involves distinguishing between normal and diseased tissue in images with complicated backgrounds and/or ‘noise’. Motion from the patient’s breathing significantly degrades images.

The team’s starting point was previous ‘numerical observers’ (algorithms), such as the channelized Hotelling observer (CHO). The CHO uses a template to decorrelate the noise in the image, and also applies linear filters (‘channels’), which mimic the human visual system. It performs well compared to radiologists when assessing medical images.

However, radiologists also look for the way the image varies in time to help them determine if a tumour is present. In this study, Trott and her colleagues developed a way for their algorithm to make use of time-variation in the images. It is thus referred to as a ‘4D model’, using the three spatial dimensions plus time.

Importantly, the team incorporated ‘respiratory gating’ into their algorithm. The motion from a patient’s breathing significantly degrades the quality of a diagnostic image. Respiratory-gated imaging uses a signal from breathing to time when the image data are collected (typically at the end of exhalation): the resulting images are of higher quality than images made without gating.

The researchers created a set of realistic simulated PET images with a range of lesion sizes, severities, locations and degree of respiratory motion. To this they applied their new 4D algorithm, using gated imaging; the standard CHO algorithm, on non-gated images; and the CHO algorithm on motion-corrected images. The 4D algorithm, using gated imaging, proved superior to the other two techniques: on average, it improved the signal-to-noise ratio of the image by 48.6%, as compared to the non-gated method, while the 3D methods on motion-corrected images showed a corresponding improvement of 31.0%. (The 4D method avoids registration and interpolation inaccuracies that can occur in the motion-corrected imaging, effects that lead to lower contrast and poorer spatial resolution.)

These results are encouraging. The next step will be to test the 4D model against the performance of real radiologists with real patient images.

In a related project, Trott has begun working with physicists in the Radiation Physics Laboratory at the University of Sydney who are developing a low-cost computed tomography (CT) radiotherapy scanner. She is helping them design methods for rapidly imaging a tumour and tracking its motion and deformation so that radiotherapy can be optimally timed.
Interdisciplinary Research Case Study

**COEPP-CAASTRO JOINT WORKSHOP**

Katherine Mack (University of Melbourne)

Dark matter, dark energy, neutrinos and theories of gravity: all are areas in which the work of particle physicists complements that of astrophysicists. The ARC Centre of Excellence for Particle Physics on the Terascale (CoEPP) and the ARC Centre of Excellence for All-sky Astrophysics (CAASTRO) held their first joint workshop in 2012, to explore their common interests. The second joint workshop, run over 28–30 September 2014, was held to make concrete plans for an exciting new opportunity in dark-matter research.

The workshop was held in the town of Great Western in rural Victoria. As well as bringing together local and international experts on all aspects of dark matter research, the workshop was also designed around introducing the scientific community to a proposal for a dark-matter detector in the Stawell gold mine, close to Great Western. Attendees at the workshop included scientists from Italy’s Istituto Nazionale di Fisica Nucleare (INFN), a research agency dedicated to the study of the fundamental constituents of matter, and the Science Attaché for the Italian Embassy in Canberra.

Members of CAASTRO and CoEPP from Melbourne and Swinburne Universities had begun talks with the managers of the Stawell mine in 2013, to explore the possibility of using a portion of the mine as an underground physics laboratory. While dark-matter detectors are already operating underground in many locations in the northern hemisphere, this will be the first such detector in the southern hemisphere, and will help us to confirm possible dark-matter signals found at other sites (such as INFN’s laboratory at Gran Sasso in central Italy). Having our own dark-matter detector will give Australia much greater involvement in the worldwide endeavour to identify dark matter and study its properties.

Discussions at the CoEPP-CAASTRO workshop touched upon the radiation and cosmic-ray-shielding conditions at the Stawell mine, both of which appear to be acceptable. The next steps will be to form an official collaboration and secure funding for equipment and researchers. Both the local council and the community of Stawell have shown their support for the enterprise.

Research talks at the workshop made it clear that there is still a lot of work to be done in our understanding of dark matter. On the observational side, inconsistencies between models and observed properties of small-scale dark-matter systems (such as dwarf galaxies) are still vexing, as pointed out by invited speaker Manoj Kaplinghat (University of California Irvine). Geraint Lewis (University of Sydney) described an even more puzzling problem: the discovery of great co-rotating planes of satellite galaxies around the Milky Way and Andromeda, in apparent disagreement with expectations of dark-matter behaviour. Other researchers spoke about work to study dark matter in the cosmic microwave background, and prospects for detecting dark matter indirectly, through neutrino and gamma-ray signals.

On the theoretical side the field is still open for new ideas about dark matter’s fundamental nature. Several speakers discussed dark-matter models beyond the ‘supersymmetric neutralino’, which is looking less and less favoured due to the failure of the Large Hadron Collider to detect signatures of other ‘supersymmetric’ particles.

The second day of the workshop was devoted mainly to the nuts and bolts of designing and building a dark-matter detector, and highlighted the opportunities for CoEPP and CAASTRO researchers to be part of this emerging collaboration between Italy and Australia. This prospect of direct detection, coupled with the prospects of indirect detection via cosmic rays, gamma rays or neutrinos, makes it an exciting time to be studying dark matter in Australia.

Interdisciplinary Research Case Study

**PAINTING NEUTRINOS INTO A CORNER**

Signe Riemer-Sørensen (University of Oslo)

As elementary particles, neutrons – ‘little neutral ones’ – are not newcomers: they were proposed by physicist Wolfgang Pauli in 1930 and revealed by experiment in 1956. The ‘Standard Model’ of particle physics says they are massless; however, experiments and observations have shown otherwise. This makes the neutrino the only confirmed particle that doesn’t fit the Standard Model (which is otherwise extremely successful).

The neutrino mass is not well constrained, either. Pinning it down would help us to better understand how neutrons fit into the family of fundamental particles. But even talking of ‘the’ neutrino mass is misleading. Neutrinos come in at least three kinds, or ‘flavours’, which can transform into each other. Experiments show that there are mass differences between them. Current particle-physics experiments can only measure the mass differences, not the masses themselves. Cosmology, however, is sensitive to the combined mass of the neutrinos, because that affects the formation of large-scale structure (the distribution of galaxies).

Observations of neutrinos from the Sun, the atmosphere, and nuclear reactors have put the lower limit for the combined mass at 0.05 eV, an amount equivalent to a tenth of a millionth of the (already tiny) mass of the electron.

The strongest upper limits come from cosmology. Until recently, the best figure was 0.23 eV. That was obtained from the measurements of the cosmic microwave background by the Planck spacecraft, coupled with information about the patterns in which galaxies are clustered from four galaxy redshift surveys. Two of those surveys were done in Australia: the 6dF Galaxy Survey of more than 125,000 galaxies, made with the 1.2 m UK Schmidt Telescope, and the WiggleZ survey of almost 240,000 galaxies, carried out with the 4-m Anglo-Australian Telescope.

Now CAASTRO affiliate Signe Riemer-Sørensen (University of Oslo), CAASTRO Associate Investigator David Parkinson (University of Queensland), and the leader of CAASTRO’s Dark theme, Tamara Davis (University of Queensland), have painted neutrinos even further into a corner. By adding extra data from the WiggleZ survey to the dataset used by the Planck team, they have pushed the upper mass limit down to 0.18 eV – an improvement of over 25%.

This limit is an order of magnitude better than laboratory experiments will be able to obtain in the next decade. The additional data was the ‘matter power spectrum’ from WiggleZ – a function that captures information about the distribution of matter on different scales. This function contains significant information about the neutrino mass. This is because when large-scale structures, clusters, sheets and filaments of galaxies, formed in the early Universe, neutrinos would have slowed down the formation of the smaller features of that structure, ‘washing out’ the smaller scales in the matter power spectrum that we observe today. They also affect the growth of structure by altering how the expansion rate of the universe changes with time. So from the details of the matter power spectrum we can infer an upper limit for the sum of neutrino masses.

Using the matter power spectrum is complex: Riemer-Sørensen and her colleagues used only the part of it that applies to matter forming structures on very large scales (much larger than clusters of galaxies, k < 0.2 h Mpc^−1). When matter begins to condense to form ‘small’ structures (such as a cluster of galaxies), the physics becomes complicated. We could obtain a tighter constraint on the neutrino mass, even from existing data, if there were better simulations of how this small-scale structure grows: this is something CAASTRO researchers are also working on. Looking forward, astronomers expect to obtain tighter limits on the neutrino mass from the Euclid spacecraft (scheduled to launch in 2020) and the Square Kilometre Array radio telescope (to be built in Australia and South Africa from 2018), both of which will detect tens of millions of galaxies.
Radio pulsars are a form of neutron star, a ball of condensed ‘neutron matter’ only a few tens of kilometres in diameter that is formed by the explosion of a ‘regular’ star. They possess a strong magnetic field and emit a beam of radio waves along the axis of that field. If the magnetic axis is not aligned with the pulsar’s rotation axis, as the pulsar spins we may detect the beam of radio waves flashing periodically over the Earth. This is the pulsar’s ‘pulse’.

Forty-five years after pulsars were discovered, astronomers are still debating the exact mechanism by which a pulsar produces its radio beam. In part that is because, as pulsars are small and distant, we have not been able to measure the size of the emission region that generates the radio beam or its altitude above the pulsar surface. CAASTRO Partner Investigator Ue-Li Pen (University of Toronto) and Associate Investigator Jean-Pierre Macquart (Curtin University), along with their collaborators, have now invented a new technique for measuring the location of the pulsar emission with extraordinary accuracy. They have, for the first time, been able to directly and precisely detect the motion of the emission region as the pulsar rotates.

The basis of their technique is something that would often be considered a problem: the ‘interstellar medium’, the extremely thin gas that lies in space between the stars. The gas is ionised (the electrons have been removed from the atoms) and causes the image of a star to scintillate (twinkle) and break up, just as the Earth’s atmosphere does to the image of a star. In fact, this is the highest-resolution measurement ever found, mostly in archival data. In 2014, CAASTRO PhD candidate Emily Petroff (Swinburne University) became the first person to detect a fast radio burst in ‘real time’. (See page 32 for more details.)

Finding more fast radio bursts, and, ultimately, determining what they are, has been a key science driver behind the upgrade of the University of Sydney’s Molonglo Observatory Synthesis Telescope (MOST), carried out with the help of Swinburne University and the Australian National University, in a project facilitated by CAASTRO.

The telescope has kept its basic structure, a 1600 m ‘trough’ of wire mesh that captures radio waves. However, it has a new ‘back end’: a cluster of signal-processing computers that incorporate off-the-shelf graphics processing cards (GPUs). These cards have become very cheap because of their wide use in the gaming industry. The backend can handle up to 22 gigabytes of data per second, and in the course of a year will process almost an exabyte (10^18 bytes).

As well as entering the era of ‘big data’, the telescope has also had a change of name, going from MOST to (appropriately) UTMOST. UTMOST is well suited to doing widefield, high-time-resolution searches for fast radio bursts. The FRB search program is set up to operate at the same time as every other program being run on the telescope so that, for instance, while the telescope is looking for fast radio bursts, the same set of data is being combed through for pulsars. Future radio telescopes will have to carry out such simultaneous searches: UTMOST demonstrates how that requirement can be met.

A fast radio burst could easily be confused with, or obscured by, an unwanted man-made radio signal, radio-frequency interference or RFI. Being only 50 km from Canberra, UTMOST receives RFI from several sources, including discharges from electric fences, vehicles, and electrical equipment operating on farms. One of the most prominent sources is mobile-phone calls, which are present about 5–10 per cent of the time and which can affect up to half of the region of spectrum over which the telescope observes (currently, 836–856 MHz).

Fortunately, mobile-phone signals have a characteristic appearance: they are bright, come from directions that clearly indicate their terrestrial origin, and fall into a well defined frequency range, so they are easily distinguished from the radio waves the telescope receives from the cosmos. Because the telescope captures so much data, storing it all is impractical. The backend that processes it does so in real time, reducing its volume by a factor of a thousand, a million or even a billion, depending on the type of observation being made. So the RFI needs to be recognised and excised from the data in real time too.

This process works extremely well, as the Figures show. The RFI thus removed, UTMOST has a clearer view of the Universe, and will have a better chance of detecting fast radio bursts.
The MWA is not just a tool for investigating the cosmos: it is the first radio telescope able to image the Earth’s ionosphere. MWA observations have revealed large-scale, periodic, banded plasma structures strongly elongated along the Earth’s magnetic field that appear to be ‘whistler ducts’ — structures never imaged before. Some of the gas molecules in the Earth’s atmosphere are ionised, having had one or more of their electrons stripped away. Most commonly this is caused by the Sun’s radiation. At an altitude of 100 km, less than one molecule in a million is ionised; at 1000 km, it’s one in ten. The ionised component of the atmosphere is known as the ionosphere. At its outer edge (around 1000 km) it merges into the plasmasphere, a region of cold, dense plasma in the innermost part of the Earth’s magnetosphere.

The ionosphere affects low-frequency radio-astronomy observations, those below 1 GHz. This was noticed at the very beginnings of the science: Hey et al. (1946) observed the radio source Cygnus A scintillating at 60 MHz. The ionosphere is opaque to radio waves of the lowest frequencies. At the Murchison Radio-astronomy Observatory (MRO) in Western Australia (lat -27°, lon 116°) the cut-off frequency is about 10 MHz for observations at the zenith.

The ionosphere also produces refraction (shifting the positions of celestial radio sources), dispersion (where signals of different frequencies experience different signal delays), and Faraday rotation (twisting a cosmic field of position offsets for EoR 2013-10-15, a patch of sky centred on (α, δ) = (0°, −26.7°) near zenith, taking snapshots every 2 minutes. The data were obtained over a 30.72 MHz band centred at 183 MHz. The observations followed moderate geomagnetic storm activity that had occurred about 12 hours earlier.

A member of the MWA Collaboration who reduced the data noticed a high amplitude of oscillatory motion, shape distortions and scintillations of the point sources in the images. Some sources were observed occasionally to split into two, suggesting multipath propagation. In terms of the level of distortions observed, this dataset (hereafter referred to as EoR 2013-10-15) is one of the most extreme so far imaged with the MWA. Loi decided to investigate it.

EoR 2013-10-15 displays a striking pattern of over- and under-densities in the ionosphere, two of the best investigated are plasma bubbles and ‘whistler ducts’ — structures never imaged before. These are the first direct wide-angle observations of these structures. This groundbreaking work shows that the MWA is an outstanding instrument for probing the ionosphere.
National Innovation Priority Case Study: International Collaborations

FIRST REAL-TIME DETECTION OF A ‘FAST RADIO BURST’

Emily Petroff (Swinburne University)

They last just a few milliseconds, but in that brief time they give out the energy the Sun does in a year. ‘They’ are ‘fast radio bursts’ or FRBs, first detected in 2007 in archival data from CSIRO’s Parkes radio telescope in New South Wales. As of the end of 2014, nine FRBs had been reported in the scientific literature: eight were found with Parkes, and the ninth with the Arecibo radio telescope in Puerto Rico.

FRBs manifest as a single spike of radio waves. Like signals from the radio-emitting stars called pulsars, the FRB signal is dispersed in frequency as it interacts with electrons in the space through which it travels. The radio waves at lower frequencies are slowed down more than the ones at higher frequencies, so they reach us later: the further the radio waves travel, the greater this time delay becomes. Expressed as a ‘dispersion measure’, the delay is used to calculate the distance of the source. All nine published FRBs appear to come from far beyond our Galaxy, perhaps as much as seven billion light-years away.

The recorded FRB signals are generally of the order of a jansky, which is fairly strong for a cosmic radio signal. The recorded FRB signals are generally of the order of a jansky, which is fairly strong for a cosmic radio signal.

On 14 May this year, a team led by Emily Petroff, a CAASTRO PhD candidate at Swinburne University, made the first real-time detection of an FRB. The finding was made with the Parkes radio telescope while Petroff and her colleagues were re-observing a field containing a known FRB, as part of an observing campaign to see if bursts repeat: however, the burst of 14 May (FRB 140514) has a dispersion measure significantly different from that of the earlier burst (FRB 110220), so the researchers were sure they were looking at a new object. The new burst’s dispersion measure suggested that its source was up to 5.5 billion light-years away.

Petroff and her colleagues were using observing instrumentation developed for the High Time Resolution Universe survey, which had been operating successfully at Parkes since 2008. This allows pulsars, and now FRBs, to be detected in real time. The data-processing pipeline identified the incoming signal as an FRB within 10 seconds of its arrival, and immediately sent an alert email to observers associated with the project.

Over the next few hours, telescopes around the world swung into action. Follow-up radio observations were made with four telescopes (Parkes itself; CSIRO’s Australia Telescope Compact Array; the Giant Metawave Radio Telescope in India; and the Effelsberg Radio Telescope in Germany) and optical observations with six (the Swope and Baade telescopes at Las Campanas observatory in Chile; the Samuel Oschin Telescope at Palomar Observatory in the USA; the ANU’s SkyMapper telescope in Australia; the Nordic Optical telescope in La Palma; one of the Magellan telescopes in Chile; and the Keck I telescope in Hawaii). The MPA/ESO telescope at La Silla in Chile made both optical and near-infrared observations of the field; NASA’s Swift X-ray space telescope studied it at X-ray and ultraviolet wavelengths.

This intense scrutiny revealed no optical, infrared, ultraviolet or X-ray counterparts to the radio burst. That in itself rules out some possible FRB mechanisms: long gamma-ray bursts and nearby (z < 0.3) supernovae. However, short gamma-ray bursts could still be contenders, as could giant flares from magnetars (neutron stars with extremely strong magnetic fields) or ‘blitzars’, neutron stars collapsing to form black holes.

Importantly, this Parkes observation was the first to measure an FRB’s polarisation, a parameter not recorded in the archived data in which all previous FRBs had been found. The radio emission from the new burst was more than 20% circularly polarised; no linear polarisation was detected. Petroff and her colleagues think that this polarisation is likely to be intrinsic to the source, rather than being created by an external mechanism such as scintillation. Its presence does not tip the scales in favour of any of the possible FRB progenitors, but it does suggest that there were magnetic fields near the burst’s source.

The way forward for FRB studies is to find more FRBs. CAASTRO has two projects to do so: SUPERB, the SUrvey for Pulsars and Extragalactic Radio Bursts (described on page 14), which began on the Parkes telescope in 2014, and a similar survey that will run on the upgraded Molonglo Observatory Synthesis Telescope (described on page 29). On the theory side, any hypotheses about the origin of FRBs must now take into account the polarisation data from Petroff et al.’s study, and the limits the follow-up observations have placed on the FRB’s multi-wavelength ‘afterglow’.
National Innovation Priority Case Study: Developing a Strong Base of Skilled Researchers

MWA BUSY WEEKS FOR KNOWLEDGE TRANSFER

Randall Wayth (Curtin University)

The Murchison Widefield Array (MWA) has been developed by an international collaboration of 15 institutions (many of them CAASTRO nodes and partners) in Australia, India, New Zealand, and the United States. One hundred and eighty researchers take part. Just bringing the telescope into operation in 2012–2013 involved two dozen researchers, in three countries. How could the efforts of this large, distributed team best be harnessed? One answer was Busy Weeks: week-long meetings dedicated to making rapid progress on problems.

A Busy Week brings as many MWA researchers as possible together in a single room. Those who can’t be there join the meeting via CAASTRO’s videoconferencing system. Participants dedicate themselves to the task in hand: there are no distractions. MWA Busy Weeks originally focused on problems associated with commissioning the telescope, but they now deal mostly with the major MWA projects; they are also the quickest way for participants to ‘up to speed’ about the status of others’ work.

Busy Weeks provide rapid communication and immediate feedback, speeding up the process of solving problems. They particularly help to bring new team members ‘up to speed’ about the status of projects; they are also the quickest way for participants to identify who in the large MWA team holds the knowledge and experience needed to solve a problem. In addition, they foster broader discussion and let participants make serendipitous connections, links that would probably not have been made any other way.

The value of the Busy Weeks is shown by an example. At one of these meetings participants were discussing a long-standing, vexatious issue: how the ionosphere affects the MWA’s observations, and how best to correct for this. Plots of the effects were shown, and an idea proposed for dealing with them. Within 24 hours the team had made simulations showing how well this solution would work. The proposed solution was adopted and has been used across the board by the MWA team ever since. The case is closed, thanks to a Busy Week.

One of CAASTRO’s key industry collaborations is with Voyages Indigenous Tourism Australia, which operates the Ayers Rock Resort at Uluru. The Indigenous Land Corporation (ILC) owns Voyages, and handles tourism and resorts on its behalf. Voyages has a strong commitment to social responsibility, and all profits from its business activities go towards supporting the ILC’s Indigenous programs across Australia.

From March to November 2014 a CAASTRO Astronomer in Residence was based at Uluru on a fortnightly roster. Astronomers at all levels, from most of our nodes and partner organisations, participated. Each fortnight, a new astronomer resided at Uluru sharing their knowledge and enthusiasm for astrophysics with the locals and tourists, and on the @CAASTROatUluru Twitter account. The astronomer works closely with Mike Dalley, Voyages’ ‘Head SkyTalker’, who manages the astronomy components of the tourism offerings at the resort. Mike is a CAASTRO Affiliate member. Two of the tours offered by Voyages are about experiencing the night sky: one is for families and the other is aimed at people who are looking for more of that ‘wow’ factor. The flagship event at Uluru is the Sounds of Silence dinner, where the audience sips sparkling wine while watching the sunset over Uluru to the sound of a didgeridoo, and then sits down to a buffet dinner.

The Uluru Astronomer in Residence program is a unique experience for all involved. The astronomers spend two weeks in an amazing part of Australia under the darkest skies most have ever seen, talking to a large number of people who have a real curiosity and interest in our research.

The astronomers who participated in 2014 were: Dr Tara Murphy, University of Sydney; Professor Ray Norris, CSIRO; Dr Sean Farrell, University of Sydney; Dr David Lagattuta, Swinburne University; Mr Joe Callingham, University of Sydney; Dr Ned Taylor, University of Melbourne; Mr Syed Ashraf Uddin, Swinburne University; Dr Irakis Konstantopoulos, Australian Astronomical Observatory; Dr Richard Scalzo, Australian National University; Dr Anna Kapinska, University of Western Australia; Ms Emily Petroff, Swinburne University; Dr Jamie Farnes, University of Sydney; Dr Martin Bell, CSIRO; and Ms Jessica Bloom, University of Sydney.

In August 2014 CAASTRO and Voyages also hosted the inaugural ‘Uluru Astronomy Weekend’, as part of National Science Week.
CAASTRO expects to have another enriching and rewarding 12 months with many stimulating activities and research discoveries.

CAASTRO RESEARCH PROGRAM

Evolving Theme

2015 promises to be another very exciting year for science in the Evolving Theme, as we build on work done in 2014. The SAMI Galaxy Survey is now in full operation. More than 70 nights of observations have resulted in spatially resolved surveys of over 1000 galaxies. Following the project’s ‘early data release’ in 2014, the astronomical community is now analysing the richness of the SAMI data. During 2014 over 350 hours of observing were completed for the MWA Epoch of Reionisation (EoR) survey, generating some 467 TB of data. The MWA EoR collaboration has developed three independent and parallel data-reduction pipelines, two for the targeted EoR fields and one for the driftscan observations. CAASTRO researchers are leading the development of a pipeline for the MWA Realtime System. This pipeline, now operational, will be applied to the MWA EoR survey data during 2015, with the goal of measuring the power spectrum of redshifted 21-cm intensity fluctuations. 2015 will see the first results from CAASTRO’s new intensity-mapping project, which is designed to study the HI content of the Universe at a wide range of cosmic times. Intensity mapping involves averaging together the neutral hydrogen (HI) emission from large numbers of galaxies observed in a wide-area survey. The radio-survey data are then combined with additional information from optical redshift surveys and from galaxy simulations. The cross-correlation of redshifted 21-cm intensity with galaxies identified optically will allow us to measure HI at high redshift and study its distribution in galaxies. The first phase of the project will include observations and modelling of these datasets. There is currently a gap in our knowledge of how gas evolves in galaxies in the crucial redshift range of 0.1 to 1; intensity mapping will enable CAASTRO researchers to bridge this gap. The project will have implications for the science goals and design of the Square Kilometre Array radio telescope.

Dynamic Theme

In 2015 researchers in the Dynamic Theme are looking to regularly detect ‘fast radio bursts’ with a combination of telescopes, including the Parkes 64-m telescope, the new UTMOST facility (the upgraded Molonglo Observatory Synthesis Telescope), the Murchison Widefield Array, and the Giant Metrewave Radio Telescope in India. This expectation is grounded in a key result of 2014: the first detection of a fast radio burst in real time, with the Parkes radio telescope. The real-time nature of the detection allowed 12 telescopes, including NASA’s Swift X-ray space telescope, to make follow-up observations. This work was published in Petroff et al. (2015). In some ways it was a ‘dress rehearsal’ for what is to come in 2015 as new facilities to detect FRBs more regularly come online. The pipelines of the Murchison Widefield Array are now creating very widefield maps for projects such as the Epoch of Reionisation survey. These observations can also be searched for low-frequency radio transients. The challenge for these transient searches is not so much finding things that vary as determining which signals are worth further attention: ‘sorting the wheat from the chaff’. With petabytes of data to be sifted through, this is really a search for ‘needles in a cosmic haystack’.

Starting in early 2015, the SkyMapper Supernova Survey will run in parallel with the SkyMapper Main Survey. The rolling search is expected to find 100 SNe la per year by monitoring about 1000 square degrees every three to four days. The survey kicks off in March, with a live presentation on the BBC Stargazing Live series, when millions of viewers of the program will be asked to identify transient objects from streams of survey data. Target-of-opportunity observations for fast radio bursts and gamma-ray bursts will continue to override other SkyMapper observations. In addition, SkyMapper will spend some time shadowing the Parkes telescope with the hope of catching fast radio bursts in real time.

Dark Theme

During 2015 the Dark Theme will be advancing some of its newer projects as datasets build up and we welcome new postdoctoral fellows.

The peculiar-velocity surveys should result in a series of papers this year, and the 2MASX Tully-Fisher (2MTF) cosmographic survey of the local Universe will be completed (including estimations of cosmological parameters from that data). The 6-degree Field Galaxy Survey (6dFGS) peculiar-velocity results for measuring bulk flows should be finalised, and we will start modelling the local dark-matter distribution using both 2MTF and 6dFGS data. We also expect that the 2MTF dataset will be enhanced by newly released observations from the Arcturus Legacy Fast ALFA Survey (ALFALFA).

Supernovae will continue to be an important topic of study. SkyMapper will undertake regular observations for the purposes of cosmology: these will be followed up spectroscopically with the WIFES instrument. CAASTRO researchers will also carry out an important program of precision calibration of SkyMapper, cross-calibrating the telescope’s observations with results from the Dark Energy Survey and recalibrating SkyMapper’s SkyDICE instrument, which was damaged in the 2013 bushfire at Siding Spring Observatory. One of the new postdocs in the Dark Theme has started measuring the lensing magnification or supernovae in OzDES. This will allow us to remove the effect of lensing from the data, thus ‘sharpening’ the resulting Hubble diagram, and use the correlation between supernova magnitude and density to test cosmology. A second supernova postdoc will begin at the Australian National University this year to work on SkyMapper and OzDES science. OzDES is proceeding apace, with many supernovae now confirmed and the first-year paper almost complete.

Within the large-scale-structure project we now have access to a number of new datasets. In 2015 we will add value to existing survey results from projects such as WiggleZ and the 6dFGS peculiar-velocity survey by combining datasets in innovative ways. One project is a joint cosmological measurement using both peculiar velocities and the density field of the 6dFGS. Another is using the overlap region of the two largest galaxy redshift surveys, WiggleZ and the Baryon Oscillation Spectroscopic Survey, to test for new physics (and systematic errors) by measuring the baryon acoustic peak and redshift-space distortions through cross-correlation between the two surveys. Meanwhile, we are continuing to analyse the previous datasets. This analysis includes improving the ‘reconstruction’ technique that we used in 2014 to ‘sharpen’ the baryon acoustic oscillation ‘standard ruler’.

Extending the search for evidence for beyond-standard gravitational physics, we are using a combination of cosmological observations to examine scale-dependent and redshift-dependent variations of general relativity. We are also working to predict the formation of large-scale structure in Galileon models of gravity and test the predictions against the latest cosmological datasets.

Finally, there are a few papers in train that look at other types of new physics, such as new types of particles and unexpected initial conditions. This year we intend to publish our constraint on the neutrino mass derived from Planck data and large-scale-structure data. We will also release a study of how well our radio telescopes will be able to measure primordial non-Gaussianity using the integrated Sachs-Wolfe effect.

Education and Outreach

The breadth and depth of CAASTRO’s Education and Outreach program received positive feedback at the Mid-Term Review in late 2014. The coming year will see more of our successful projects, but also a number of major unique offerings. The continuing CAASTRO classics are our High School support through ‘CAASTRO in the Classroom’ and ‘Telescopes in Schools’, our public outreach efforts at Perth Astrostarf and Mount Burnett Observatory, and our partnership with Voyages Indigenous Tourism Australia for the ‘Astronomer in Residence’ and ‘Astronomy Weekend’ activities.

In 2015, our collaboration with Museum Victoria for the production of a Planetarium show will intensify as visuals are being created to tell the story of the new golden age of astronomy. This show is an exciting project for CAASTRO Education and Outreach to complete in the second half of our funding period, with the prospect of national and international distribution. We will also be deploying more ‘antenna tile’ displays of the Murchison Widefield Array (MWA) at various Australian locations, along with new signage. Further plans for activities in 2015 include an even stronger engagement in schools through fine-tuning and distributing the MWA classroom tool and through curriculum-specific research stories and career advice.
Commercialisation and Knowledge Transfer

Given CAASTRO’s primary focus on pure research, in 2015 we will approach commercialisation and knowledge transfer in innovative ways. In 2015 CAASTRO will develop an e-book to educate and assist researchers in identifying and protecting intellectual property, engaging with industry, and transferring knowledge. CAASTRO’s key strength is in knowledge distribution through formal and informal networks, which is an essential part of Australia’s economic performance. Innovation is driven by the interaction of producers and users in the exchange of both codified and tacit knowledge. The flow of information between industry, government and academia in the development of science and technology is an important economic determinant and in 2015 CAASTRO will continue to provide leadership in this area.

Joint China-Australia Astronomy Research Centre

In February 2013, the Chinese Academy of Sciences (CAS) and the Australian Department of Industry, Innovation, Science, Research and Tertiary Education (Industry) signed a Memorandum of Understanding (MoU) to collaborate on areas of common interest within astronomy, astrophysics and cosmology. The MoU required the establishment of a joint CAS/Industry working group, to monitor and encourage proposed areas of collaboration. The first meeting of the joint CAS/Industry working group took place in Nanjing, China, on 11th November 2013. At this meeting, it was resolved to establish a joint China-Australia research centre in astronomy. This envisaged as a ‘virtual’ centre, to serve as an umbrella and coordination point for bilateral and international efforts in designing and engineering new radio telescopes, which is an essential part of Australia’s economic performance. Innovation is driven by the interaction of producers and users in the exchange of both codified and tacit knowledge. The flow of information between industry, government and academia in the development of science and technology is an important economic determinant and in 2015 CAASTRO will continue to provide leadership in this area.

The specific opportunities that the Centre seeks to implement or facilitate are:

- Exchange of astronomical research staff and students between research organisations and projects in order to best engage available skills or to facilitate the development of human capital;
- The cooperative operation of telescopes whose observations may complement one another including telescopes based in Antarctica, Australia, China and other international telescopes to which Australia and China may have access;
- Joint operation of radio telescopes that may be linked as interferometers;
- The coordination and sharing of observations and related data products that will contribute to large-scale sky surveys in the optical, infrared and radio wavebands;
- The coordination of future instrumentation and telescope development programs to ensure the most efficient use of available infrastructure investment; and
- Coordination of efforts in designing and engineering the Square Kilometre Array (SKA), including pathfinders, in conjunction with and through the SKA Organisation and associated processes.

We are looking forward to seeing these plans come to life in 2015.


Steven Murray
UNIVERSITY OF WESTERN AUSTRALIA

I am a PhD student in my third year at ICRAR at the University of Western Australia (UWA), under the supervision of Chris Power and Aaron Robotham. I have been involved in CAASTRO for the duration of my PhD, working under the Dark theme. I did my time in undergraduate studies at the University of Queensland, before moving to the UWA to complete my Honours year, studying large-scale structure in the SDSS and GAMA surveys. Having been connected to world-class researchers at ICRAR in this time, I decided to stay for my postgraduate research.

My work is all about making predictions and developing tests for the nature of dark matter. I use a combination of theory and statistics to create models for the observed large-scale structure of the Universe, given different candidates for the dark matter particle. In this way, we can hope to begin to observe the different effects in large galaxy surveys, and pin down what dark matter really is.

Along with learning and applying the theory, my PhD has taught me valuable lessons like how to code up functional web applications. My first such application is now public and is being used by researchers across the globe to calculate theoretical halo mass functions for the observed large-scale structure of the Universe, given different candidates for the dark matter particle. In this way, we can hope to begin to observe the different effects in large galaxy surveys, and pin down what dark matter really is.

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Anthea King
UNIVERSITY OF QUEENSLAND

I am a joint PhD student between the University of Queensland (UQ) and the Dark Cosmology Centre of the University of Copenhagen (UC) under the supervision of Tamara Davis (UQ), Darach Watson (UC) and Marianne Vestergaard (UC). I completed my undergraduate degree in Physics at the University of Queensland, where I developed my interest in astronomy. Due to Tamara’s close involvement with the Dark Cosmology Centre in Copenhagen, the opportunity arose for me to do a joint PhD between the two Universities and I jumped at the chance. As a consequence, my time has been shared between Brisbane and Copenhagen over the last three years. I joined CAASTRO at the start of the year and have been involved with the OzDES survey.

My PhD broadly concentrates on investigating whether active galactic nuclei (AGN) are useful and viable standard-candle candidates. My initial work in this topic, investigated whether high-redshift standard candles are useful probes of dark energy. At present, I am involved in the OzDES reverberation mapping project, which is working in conjunction with the Dark Energy Survey (DES) to monitor 500 AGN. This project will not only provide black-hole mass measurements in a broad AGN population over a large redshift range, giving important insight into black-hole-galaxy co-evolution, but could potentially provide standard candle measurements out to a redshift of four. I have been working on predicting the efficiency of the OzDES reverberation mapping campaign, how to optimally select the sample and the most efficient ways to improve the survey.

Joe Callingham
UNIVERSITY OF SYDNEY

I am a second year PhD student at the University of Sydney, jointly supervised with CSIRO Astronomy and Space Science. The main focus of my PhD is contributing to the development of the Murchison Widefield Array (MWA) all-sky radio catalogue and studying the environments of young radio galaxies at low radio frequencies. The MWA is a new radio telescope that has four main science areas: study of extragalactic and Galactic sources through an all-sky survey, a transient survey, heliographic and ionospheric studies, and the search for the 21-cm signal of the Epoch of Reionisation. I am jointly supervised by Bryan Gaensler, Ron Ekers, Randall Wayth and Elaine Sadler.

I completed my undergraduate degree at The University of Sydney in 2012. I elected to remain at The University of Sydney after being offered the fantastic opportunity of being part of a team establishing a new radio telescope. My PhD work is evenly split between instrumentation and science. I have largely focussed on constraining the primary beam of the MWA, setting the low-radio-frequency flux scale for the southern hemisphere, and spectral modelling of young radio galaxies. We are entering a new era of radio astronomy with the MWA, and the wideband receivers on the back of such as the Australia Telescope Compact Array, coming online. We are moving from an era where we only had a handful of flux measurements at different frequencies to model the spectra of sources to having thousands of independent measurements. Therefore, we will soon be able to conduct one of the most comprehensive studies of the physics of radio sources.

CAASTRO has played an integral role in facilitating my PhD. Without the video-conferencing system, the fortnightly meetings that occur between the different MWA teams would be not be as successful as they are now. The video-conferencing system allows me to stay up to date with any developments with the MWA even though the operations team is based out of Curtin University. As part of the Evolving theme, I have been able to travel to conferences and busy weeks. I am very grateful to be part of CAASTRO as it has provided me access to resources and exposure to different ideas that wouldn’t have been possible without being a part of it.

Bonnie Zhang
AUSTRALIAN NATIONAL UNIVERSITY

I am a first year PhD student at the Australian National University (ANU), supervised primarily by Brian Schmidt. I also work under the supervision of Chris Lidman (AAD), Tamara Davis (University of Queensland) and Richard Scalzo, Fang Yuan and Michael Childress in the ANU supernova group. My work is in supernova cosmology, in particular as part of OzDES (the Australian team collaborating with the Dark Energy Survey), and the SkyMapper Supernova Survey.

In 2012 I completed my undergraduate degree, a Bachelor of Philosophy (Science) with Honours in pure mathematics. The PhD is a research-intensive science degree that enabled me to explore several areas of research including astrophysics, physics and mathematics. After spending 2013 travelling, I began my PhD and joined CAASTRO in early 2014.

The broad aim of my PhD research is to improve constraints on dark energy through observations of Type Ia supernovae. Over the next few years, SkyMapper is expected to measure hundreds of supernovae, forming the largest uniform sample to date at low redshift, while the Dark Energy Survey will discover an order of magnitude more at high redshift. As our sample size increases and statistical errors decrease, a major challenge is to reduce systematic errors. A dominant systematic is photometric calibration; this is an area I will focus on, particularly in relation to SkyMapper and the Dark Energy Survey.

Over the past year I have already had the opportunity to travel to conferences, workshops and telescopes, with the support of CAASTRO. I look forward to my involvement with CAASTRO over the next year, which will include spending time as an Uluru Astronomer in Residence and on the newly formed CAASTRO Student Committee.
In 2014 the CAASTRO Executive decided, in agreement with CAASTRO students, to create the CAASTRO Student Committee. This committee was established with the purpose of increasing interaction between students and the Executive, and thereby improving the overall outcomes for CAASTRO students.

The Committee consists of a member from each Node, and represents the full diversity of CAASTRO membership. This means that every student has a local representative to whom they can relate their concerns or ideas, and that the full range of values and perspectives is represented.

The first meeting of the Committee was held in October, under the Chair of COO Kate Gunn, and established the Terms of Reference and elected the first student Chair. We have established two broad objectives, namely the promotion of student involvement, and the representation of student concerns to the CAASTRO Executive.

In its first few months, the Committee has agreed on several initiatives. These include holding annual sessions with third-year and new postgraduate students to advertise the work of CAASTRO and inform students about the role they can play; the development of a student ‘cheat sheet’ to bring students up to speed on their role and the benefits of being in CAASTRO (housed on a dedicated web page); and monthly local-area gatherings for all CAASTRO students for networking and brainstorming ideas.

We look forward to a productive first year for the Committee, with clear benefits for the students of CAASTRO.

Steven Murray, University of Western Australia
Chair, CAASTRO Student Committee

2014 NEW CAASTRO STUDENTS

University of Sydney
Loi, Ms Cleo, Dynamic, Student (Honours)
SUPERVISORS: Tara Murphy (USyd)
THESES TITLES: Waves in the sky: Probing the ionosphere with the Murchison Widefield Array
McEvoy, Ms Rebecca, Evolving, Student (PhD)
SUPERVISORS: Scott Croom (USyd) Michael Pracy (USyd)
THESES TITLES: The host galaxies of luminous type II AGN

University of Melbourne
Ozgiben, Ms Sinem, Dark, Student (PhD)
SUPERVISORS: Rachel Webster (MEL) Jeremy Mould (SWIN)
THESES TITLES: Is there a third parameter in the Tully-Fisher Relation?

Australian National University
Sathyanarayana Rao, Ms Mayuri, Evolving, Student (PhD)
SUPERVISORS: Frank Briggs (ANU) Ravi Subrahmanyan (RII) Charley Lineweaver (ANU) Brian Schmidt (ANU)
THESES TITLES: On the detection of spectral ripples from the epoch of recombination
Zhang, Ms Bonnie, Dark, Dynamic, Student (PhD)
SUPERVISORS: Brian Schmidt (ANU) Chris Lidman, Tamara Davis, Richard Scalo, Fang Yuan and Michael Childress,
THESES TITLES: Joint photometric calibration and cosmology analysis of Type Ia supernovae in the SkyMapper and Dark Energy Survey samples

ICRAR | Curtin University
Rogers, Ms Seonaid, Outreach, Student (undergrad)
SUPERVISORS: Wiebeke Ebeling (Curt) Steven Tingay (Curt)
THESES TITLES: Visualisations of astronomical all-sky data sets for researchers and public audiences

Swinburne University of Technology
Bhandari, Ms Shivani, Dynamic, Student (PhD)
SUPERVISORS: Matthew Bailes, Willem van Straten, Evan Keane (SWIN)
THESES TITLES: The radio Universe at 1000 frames/sec

Codoreanu, Mr Alexandru, Evolving, Student (PhD)
SUPERVISORS: Emma Ryan-Webber (SWIN) Michael Murphy (SWIN) and Neil Crighton (SWIN)
THESES TITLES: Chemical fingerprints in the highest-redshift quasar absorption systems: Probing the epoch of hydrogen reionisation
Garcia, Miss Angela, Evolving, Student (PhD)
SUPERVISORS: Emma Ryan-Webber (SWIN) Edoardo Tescari (MEL) Stuart Wyithe (MEL)
THESES TITLES: Diagnosing Hydrogen Reionization with metal absorption line ratios.
Morello, Mr Vincent, Dynamic, pre-PhD Student, Supervisors: Willem van Straten, Matthew Bailes (SWIN)
THESES TITLES: Milking the Radio Sky for Pulars and Transients
Venkatraman, Mr Vivek, Dynamic, pre-PhD Student, Supervisors: Matthew Bailes, Willem van Straten, Evan Keane (SWIN)
THESES TITLES: Next generation instrumentation for studies of Pulars and Fast Transients with the SKA
Pouhi, San-Rahul, Evolving, Pre-PhD Summer Student, Supervisors: Jeremy Mould (SWIN)
THESES TITLES: SAMI
Tabbara, Ms Dana, Dynamic, Student (undergrad)
SUPERVISORS: Matthew Bailes (SWIN)
THESES TITLES: PDR calculations

University of Queensland
Hinton, Mr Samuel, Dark, Pre-PhD Summer Student, Supervisors: Tamara Davis (UQ)
THESES TITLES: Measuring 2D BAO with WiggleZ
King, Ms Anthea, Dark, Student (PhD)
SUPERVISORS: Tamara Davis (UQ) Darch Watson (UCPH) Marianne Vestergaard (UCPH)
THESES TITLES: Active Galactic Nuclei as high-redshift standard candles
O’Neill, Mr Conor, Dark, Student (Honours)
SUPERVISORS: Tamara Davis (UQ) Chris Lidman (AAO)
THESES TITLES: Cosmological Investigations: Optimising novel observation techniques in OzDES and examining the precision of cosmological probes

Thomas, Mr Adam, Evolving, Student (Hons)
SUPERVISORS: Michael Drinkwater (UQ)
THESES TITLES: Searching for ram-pressure stripping in galaxy clusters with the SAMI Galaxy Survey

Thomson, Ms Sarah, Dark, Student (Honours)
SUPERVISORS: David Parkinson (UQ) Ray Norris (CSIRO)
THESES TITLES: Probing the Early Universe with Large Area Radio Surveys

ICRAR | University of Western Australia
Valcin, Mr David, Evolving, Dark, Student (pre-PhD)
SUPERVISORS: Chris Power (UWA)
THESES TITLES: Supercomputer simulations of galaxy formation to make predictions for the SAMI (Sydney AAO Multi-object IFU) Galaxy Survey

CONTINUING CAASTRO STUDENTS

University of Sydney
Eromanga Ademern, Evolving, Honours
SUPERVISORS: Sean Farrell, Anne Green
THESES TITLES: A Population Study of Ultra-Luminous X-Ray Sources

Jessica Bloom, Evolving/Dark, PhD
SUPERVISORS: Joss Bland-Hawthorn, Scott Croom, Lisa Fogarty
THESES TITLES: Dynamical Interactions in Nearby Galaxies

Joseph Callingham, Evolving, PhD
SUPERVISORS: Bryan Gaensler, Sean Farrell, Randall Wayth, Ron Ekers
SUPERVISORS: An MWA Source Catalogue: Compact Steep Spectrum and Gigahertz Peaked Spectrum Sources at Low Radio Frequencies
Marcin Glowacki, Evolving, PhD
SUPERVISORS: Matthew Bailes, Willem van Straten
THESIS TITLE: Studies of HI Absorption Against Distant Radio Sources with ASKAP

Fabian Jankowski, Dynamic, PhD
SUPERVISORS: Scott Meyer, Willem van Straten
THESIS TITLE: The Radio Universe at 1000 frames per second

Aina Musaeva, Evolving, PhD
SUPERVISORS: Elaine Sadler, Sean Farrell, Bärbel Koribalski
THESIS TITLE: Intermediate Mass Black Holes in Dwarf Galaxies

Sarah Reeves, Evolving, PhD
SUPERVISORS: Elaine Sadler, Tara Murphy, Bärbel Koribalski
THESIS TITLE: HI and OH absorption line studies of nearby galaxies

University of Melbourne
Loren Bruns Jr, Evolving, PhD
SUPERVISORS: Stuart Wyithe, Rachel Webster
THESIS TITLE: Lyman alpha emitters as a probe of galaxy formation and ionisation history

Catherine De Burgh-Day, Dark, PhD
SUPERVISORS: Rachel Webster, Ned Taylor, Andrew Hopkins
THESIS TITLE: Direct Shear Mapping

Antonios Katsianis, Evolving, PhD
SUPERVISORS: Stuart Wyithe, Edoardo Tescari
THESIS TITLE: Feedback and Evolution of High Redshift Galaxies

Jack Line, Evolving, PhD
SUPERVISORS: Rachel Webster, Daniel Mitchell
THESIS TITLE: Detecting the Power Spectrum of the 21-cm Emission of Hydrogen from the Epoch of Reionisation

Sinem Ozdilgen, Dark, MSc
SUPERVISORS: Rachel Webster, Jeremy Mould
THESIS TITLE: Calibrating the Tully-Fisher relationship

Tristan Reynolds, Evolving, Honours
SUPERVISORS: Rachel Webster
THESIS TITLE: Detection of EoR

Nastaran Rezaee, Evolving, MPhil
SUPERVISORS: Stuart Wyithe, Daniel Mitchell
THESIS TITLE: Simulations of Foregrounds in MWA Epoch of Reionisation Observations

Onifer Riding, Evolving, PhD
SUPERVISORS: Rachel Webster, Daniel Mitchell
THESIS TITLE: Extremely Low Frequency Radio Astronomy Techniques to Confirm Epoch of Reionisation Theories

Australian National University
Manisha Caleb, Dynamic, PhD
SUPERVISORS: Frank Briggs, Matthew Bailes, Brian Schmidt
THESIS TITLE: A Pursuit for Celestial Radio Sources

Sarah Leslie, Evolving, Pre-PhD
SUPERVISORS: Elaine Sadler, Scott Croom, Julia Bryant, Lisa Kewley
PROJECT TITLE: A radio continuum study of SAMI galaxies

Benjamin McKinley, Evolving, PhD
SUPERVISORS: Frank Briggs, Brian Schmidt, Randall Wayth
THESIS TITLE: A multifrequency, spatially resolved study of nearby radio galaxies at low frequencies

Sharon Rapoport, Dynamic, PhD
SUPERVISORS: Brian Schmidt
THESIS TITLE: Gamma Ray Bursts and Exploding Stars

Jonghwan Rhee, Evolving, PhD
SUPERVISORS: Frank Briggs, Philip Lah, Jayaram Chengaluri, Brian Schmidt
THESIS TITLE: Cosmic Hydrogen -- Fuel for Star Formation and Tracer of Baryon Flow

ICRAR | Curtin University
Mehran Moosammaras, Evolving, MSC
SUPERVISORS: Steven Tingay, Randall Waythe, Peter Hall at ICRAR, Curtin.
THESIS TITLE: Radiometric Receiver for Measuring Redshifted 21-cm Hydrogen Monopole during EoR

Samuel Oronsaye, Dynamic, PhD
SUPERVISORS: Steven Tingay, Steve Ord, Ramesh Bhat, Steven Tremblay
THESIS TITLE: Survey for Pulsars with the MWA

ICRAR | University of Western Australia
Scott Meyer, Evolving, PhD
SUPERVISORS: Martin Meyer, Danail Obreschkow
THESIS TITLE: Investigating the Tully-Fisher relation and galaxy kinematics through neutral Hydrogen spectral line stacking techniques

Steven Murray, Evolving, PhD
SUPERVISORS: Chris Power, Aaron Robotham, Simon Driver, Lister Staveley-Smith
THESIS TITLE: Non-Parametric Descriptions of Dark Matter Haloes

Paul Scott-Taylor, Evolving, Dynamic, PhD
SUPERVISORS: Danail Obreschkow
THESIS TITLE: Large-scale computer simulation of radio continuum emission

Swinburne University of Technology
Andrew Johnson, Dark, PhD
SUPERVISORS: Chris Blake, David Wiltshire and Tamara Davis
THESIS TITLE: Testing Non-Standard Cosmological Models with Galaxy Surveys

Emily Petroff, Dynamic, PhD
SUPERVISORS: Willem van Straten, Matthew Bailes, Simon Johnston
THESIS TITLE: Our Dynamic Galaxy

Syed Uddin, Dark, PhD
SUPERVISORS: Jeremy Mould, Chris Lidman and Karl Glazebrook
THESIS TITLE: Improved Constraints on Cosmology from Type Ia Supernovae Hosted in Early-Type Galaxies

ICRAR | UWA | NAOC, China
Tao Hong, Dark, PhD
SUPERVISORS: Jin Lin Han, Lister Staveley-Smith
THESIS TITLE: Cosmological Structure and HI Observations 2014 CAASTRO Post Doctoral Researchers

2014 CAASTRO Annual Report

ANNUAL REPORT 2014

CAASTRO
Annual report Funds,
The following diagram shows the CAASTRO Governance structure:

A. Finkel (Chair)
Australian Research
Advisory Board
CIs, AIs, staff, students

B. Schmidt
E. Sadler
Node
CAASTRO Director / U.Syd

In 2014, the CAASTRO Executive met 9 times, including face-to-
face meetings at Swinburne, the University of Melbourne, ICRAR
University of Western Australia and ICRAR Curtin University.
During 2014 areas meetings were held in Sydney, Canberra,
Brisbane, Melbourne and Perth.
In 2014 CAASTRO’s Theme Scientists continued to add value
to the research program, and gain leadership experience and
new skills during this time. Thanks must go to Dr Andre Offringa (Dynamic), Dr Evan
Keane (Dynamit) and Dr Michael Childress (Dark) for their hard work
as CAASTRO Theme Scientists in 2014. Their assistance in maintaining
the Research Project Plans and
organising the Theme Meetings has
been invaluable.

The CAASTRO Executive team is responsible for the
administration of the Centre, including research output,
research training, partnerships, national and international
liaison, policies, performance, financial
management, commercialisation
and outreach. CAASTRO staff and
activities at each Collaborating
Organisation are supported by a
dedicated administrative officer.
The Management Team is:
Professor Elaine Sadler
CAASTRO Director
Professor Lister Staveley-Smith
Deputy Director
Ms Kate Gunn
Chief Operating Officer
During late 2014, the ARC undertook
its Mid-Term Review of CAASTRO,
culminating in a Panel Visit on 12
November 2014. CAASTRO was
delighted to be able to share its
achievements with the panel, and
was very comfortable with the
feedback and recommendations it
received.

In 2014, CAASTRO worked hard to
secure additional funding from the seven
participating universities and from
the National Centre of Excellence program, with
additional funding from the seven
participating universities and from
the National Centre of Excellence program.

CAASTRO is a collaboration
between The University of Sydney,
The Australian National University,
The University of Melbourne, Swinburne University of Technology,
The University of Queensland – The University of Western Australia
and Curtin University, the latter
two participating together as the
International Centre for Radio
Astronomy Research (ICRAR).
CAASTRO is funded under
the Australian Research Council (ARC)
Centre of Excellence program, with
additional funding from the seven
participating universities and from
the NSW State Government’s
Science Leveraging Fund.
As the Administering Organisation,
The University of Sydney manages
the ARC grant and distributes
funds in accordance with the signed
Collaboration Agreement. This
t agreement covers how the Centre
is managed, and how collaboration
and intellectual property
agreements are managed.
The seven collaborating universities
are represented on the CAASTRO
Executive, which meets every
six weeks via video-conference, and
twice a year at face-to-face
meetings. The Centre also has an
Advisory Board that meets twice
per year via video-conference and
annually face-to-face.

Centre Management
The CAASTRO Executive

Chief Operating Officer
K. Gunn

CAASTRO Director / U.Syd
Node
E. Sadler

Gender Action/ANU Node
B. Schmidt

AUSTRALIAN RESEARCH
COUNCIL

CAASTRO Nodes

U. Sydney
CIs, AIs, staff, students

U. Melbourne
CIs, AIs, staff, students

ICRAR
CIs, AIs, staff, students

U. Queensland
CIs, AIs, staff, students

Swinburne U.
CIs, AIs, staff, students

ICRAR
CIs, AIs, staff, students

ICRAR
UWA
CIs, AIs, staff, students

CAASTRO Governance

The following diagram shows the CAASTRO Governance structure:

Advisor Board
A. Finkel (Chair)

Independent advice

Strategic focus

CAASTRO Executive Team

CAASTRO Director / U.Syd
Node
E. Sadler

Deputy Director / UWA
Node
L. Staveley-Smith

Outreach / Curtin Node
K. Gunn

Dynamic Universe / Swinburne Node
M. Bailes

Dark Universes / U. Queensland Node
T. Davis

Evolving Universe / U. Melbourne Node
B. Tingay

ANU
CIs, AIs, staff, students

U. Sydney
CIs, AIs, staff, students

U. Melbourne
CIs, AIs, staff, students

ICRAR
CIs, AIs, staff, students

ICRAR
UWA
CIs, AIs, staff, students

CAASTRO Partners & Collaborators

CSIRO

AAO

NCI

International Partners

CAASTRO Advisory Board

The CAASTRO Advisory Board met three times in 2014, including a two-day planning meeting held in Sydney in November. At this meeting the Board assisted the
CAASTRO Executive in its preparation for the ARC Mid-Term Review. It also took time to farewell Professor Bryan Gaensler, who was a tireless foundation Director
of CAASTRO. In 2014, the Advisory Board conducted a Mini-Review of the CAASTRO Science Program utilising the skills of Professors Haynes, Illingworth, Ekers and
Freeman. This review was very useful, and provided clarity around a number of science program items. The Board has also considered matters of strategy,
responding to the changing external environment, collaboration across distances, community outreach, intellectual property and industry engagement.

They have also met with students, researchers and professional staff, as well as participating in the ARC
Mid-Term Review.

Chair
Dr Alan Finkel AM
Chancellor
Monash University

Member
Ms Soula Bennett
Director
Quantum Victoria

Member
Prof Elaine Sadler
CAASTRO Director

Member
Prof Martha Haynes
Goldsmid Smith Professor of Astronomy
Cornell University

Member
Prof Garth Illingworth
Professor of Astronomy & Astrophysics
University of California Santa Cruz

Member
Prof Tanya Monro
Deputy Vice-Chancellor (Research),
University of South Australia
(January – December 2014)

Member
Mr Guy Robinson
Systems Architect
Pawsey Supercomputing Centre, CSIRO
(January – August 2014)

Member
Prof Alistar Robertson
Emeritus Professor/
Senior Honorary Research Fellow, UWA
(January – October 2014)

Member
Prof Kenneth Freeman
Distinguished Professor of Astronomy, Australian
National University

Member
Prof Ron Ekers
CSIRO Fellow

CAASTRO Executive

Steven Tingay, Lister Staveley-Smith,
Bryan Gaensler, Elaine Sadler,
Tamara Davis, Kate Gunn,
Stuart Wyithe.

Absent: Brian Schmidt, Matthew Bailes

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Member
Prof Garth Illingworth
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University of California Santa Cruz

Member
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CSIRO Fellow

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They have also met with students, researchers and professional staff, as well as participating in the ARC
Mid-Term Review.
CAASTRO MEMBERSHIP

All members of CAASTRO agree to:

- Support the goals, objectives and research of CAASTRO.
- Accept the processes and procedures for joining, maintaining and leaving CAASTRO.
- Allow the CAASTRO Executive the right to refuse membership to any organisation or person at any time.
- Accept the intellectual property policy of CAASTRO.
- Accept the legal obligations that the Administering Organisation has with the ARC.
- Accept that membership is not transferable between individuals.
- Accept the processes and procedures for joining, maintaining and leaving CAASTRO.
- Support the goals, objectives and research of CAASTRO.

CAASTRO has defined categories of membership, and individuals and organisations must apply to the CAASTRO Executive addressing certain defined criteria to make their case for membership. The CAASTRO Membership categories are:

**Chief Investigators**

Chief Investigators (CIs) are senior researchers employed by collaborating organisations named in the CAASTRO Collaborators’ Agreement. CIs are responsible for making a substantial intellectual and strategic contribution to CAASTRO, and for supervising CAASTRO research staff, CAASTRO professional staff and CAASTRO students.

**Partner Investigators**

Partner Investigators (PIs) are senior researchers employed by partner organisations named in the CAASTRO Multi-Institute Agreement. PIs are responsible for making a substantial intellectual and strategic contribution to CAASTRO. Where appropriate, they may also co-supervise CAASTRO students.

**Associate Investigators**

Associate Investigators (AIs) are scientists who are independently funded researchers (e.g., Future Fellows, DECRA) working alongside CAASTRO researchers or Pre-PhD students whose research projects make a substantial intellectual contribution to CAASTRO. AIs are typically researchers for whom membership at the CI or PI level is not suitable for logistical or strategic reasons.

**Research Staff**

CAASTRO Research Staff are employees of a CAASTRO collaborating organisation, who are classified on the academic pay scale, and are funded at FTE 0.2 or higher from the CAASTRO budget. Research staff are responsible for producing the research, technical and outreach results associated with the CAASTRO milestones and, where appropriate, may also co-supervise CAASTRO students. CAASTRO Research Staff must have a CAASTRO CI as their line manager.

**Professional Staff**

CAASTRO Professional Staff are employees of a CAASTRO collaborating organisation who are classified on the professional/general pay scale, or are working in a professional role, and are funded from the CAASTRO budget or as an in kind contribution to CAASTRO. Professional staff are responsible for coordinating the administrative, financial, educational and outreach activities within CAASTRO. All CAASTRO Professional Staff must have a CAASTRO CI or the CAASTRO Chief Operating Officer as their line manager.

**Affiliates**

CAASTRO Affiliates are researchers who have a scientific association with CAASTRO, but who are not CIs, PIs, AIs or staff. CAASTRO Affiliates include independently funded researchers (e.g., Future Fellows, DECRA) working alongside CAASTRO researchers or other researchers who have an involvement in CAASTRO not warranting membership at the CI, PI or AI levels. Affiliates are not responsible for any CAASTRO research deliverables.

**Students**

CAASTRO students are postgraduate, honours, masters or PhD students whose research projects make a substantial intellectual contribution to CAASTRO. A CAASTRO student can be enrolled at any higher degree granting institution, but must have a CAASTRO CI as an official supervisor or co-supervisor.

**Visitors**

Visitors are academics from outside Australia who spend time working at one or more CAASTRO nodes on a research project with CIs and other research staff. A CAASTRO PI may also be a CAASTRO Visitor during time spent working at a CAASTRO node.

The University of Sydney Administering Organisation
ICRAR | The University of Western Australia Collaborating Organisation
The University of Melbourne Collaborating Organisation
Swinburne University of Technology Collaborating Organisation
The Australian National University Collaborating Organisation
ICRAR | Curtin University Collaborating Organisation
The University of Queensland Collaborating Organisation
CSIRO Partner Organisation
Australian Astronomical Observatory Partner Organisation
Max Planck Institute for Radio Astronomy Partner Organisation
California Institute of Technology Partner Organisation
The University of Oxford Partner Organisation
Durham University Partner Organisation
Max Planck Institute for Extraterrestrial Physics Partner Organisation
The University of Arizona Partner Organisation
The University of Toronto Partner Organisation
Laboratoire de Physique Nucléaire et de Hautes Energies Partner Organisation
Raman Research Institute Partner Organisation
National Computational Infrastructure Partner Organisation

CAASTRO has defined categories of membership, and individuals and organisations must apply to the CAASTRO Executive addressing certain defined criteria to make their case for membership. The CAASTRO Membership categories are:

- Chief Investigators
- Partner Investigators
- Associate Investigators
- Research Staff
- Professional Staff
- Affiliates
- Students
- Visitors
AWARDS & HONOURS

External recognition for the CAASTRO team continued in 2014 with a number of team members receiving awards and honours for their achievements.

Brian Schmidt was awarded the 2014 Breakthrough Prize for Fundamental Physics, which was presented at a ceremony in California in November 2014. The prize was shared with a larger team, including CAASTRO PIs Warwick Cough and Reynald Pain, and Als Brian Boyle and Chris Udman. The Breakthrough Prize in Fundamental Physics was founded in 2012 by Yuri Milner to recognize those individuals who have made profound contributions to human knowledge. It is open to all physicists, theoretical, mathematical, experimental, working on the deepest mysteries of the Universe.

Aina Musaeva received a 2014 Australia Day Award from the National Council of Women (NSW). Aina was one of eleven young women from across NSW (in fields as diverse as history, graphic design, science and law) chosen to receive a cash award to assist with her PhD studies. Aina received her award at an Australia Day reception and lunch held at NSW Parliament House.

Samuel Hinton, a CAASTRO student, made many astronomers’ work lives a whole lot easier and also won an award for his efforts. Samuel, a software engineering student at the University of Queensland, has received the 2014 Student Thesis prize given by the Queensland chapter of the Institute of Electrical and Electronics Engineers (IEEE). For his thesis Samuel developed new software for a CAASTRO project, the OzDes redshift survey. Called Arcfa, the software greatly speeds up the process of obtaining redshifts from the OzDes observations. Samuel’s thesis also won the GroundProbe Prize (‘Best in microwave, photonics and communications’) at the UQ Innovation Showcase event in November.

CAASTRO was delighted to receive a Silver Pleiades Award in 2014. The awards were launched in August 2014 during the Australian Women in Astronomy workshop. Inspired by the UK’s Athena Swan program, they are given by the Astronomical Society of Australia (ASA) to organisations that take steps to improve gender equity in the workplace. CAASTRO was one of only two organisations to win a Silver Pleiades award. It was also gratifying that all our collaborating Universities also achieved Bronze Status, and CAASTRO’s two Australian Partner organisations also gained awards with a Silver award to AAO and Bronze to CSIRO Astronomy and Space Science.

Anthea King and Emily Petroff, both were student prize winners at the Astronomical Society of Australia (ASA) scientific meeting in July 2014. Ken Freeman, a member of the CAASTRO Advisory Board, was awarded the 2014 Gruber Foundation Cosmology Prize for his work in Near Field Cosmology.

GENDER ACTION COMMITTEE

By Professor Brian Schmidt, CAASTRO Gender Action Committee Chair

From its establishment in early 2011, the CAASTRO Executive has considered itself a force for gender equality and has had strong oversight of gender initiatives and the monitoring of Key Performance Indicators (KPIs) and outcomes. For example we have offered all positions part-time in CAASTRO since 2011. In 2013 the CAASTRO Executive considered its KPIs in relation to its gender program and decided that it was falling short in a number of desired outcomes. The CAASTRO Executive decided to form the CAASTRO Gender Action Committee to address these issues and Professor Brian Schmidt agreed to lead the Committee. 2014 saw the Gender Action committee undertake its first activities, with its remit to contribute to the development of strategies to meet Gender Action challenges to maximise the proposed goals and objectives of the Centre. This includes making recommendations on ways in which CAASTRO can balance its gender representation, and boost opportunities for our female staff and students, and monitor progress.

The Gender Action Committee provides broad representation from its membership and different levels within the centre, including members from different member organisations, different genders and nationalities. The committee is made up of Elainé Sadler (USyd), Rachel Webster (UMelb), Kathryn Trott (ICRAR/Curtin), Fang Yuan (ANU), Evan Kopeikin (Swinburne), Irakis Konstantopolous (AAO), Jessica Bloom (USyd), Kate Gunn (USyd) and Brian Schmidt (ANU, Chair). The Committee met face to face for half a day, and then three times during the year for a two hour videoconference. The creation of the CAASTRO Gender Action Committee has fast-tracked many of our gender initiatives.

CAASTRO has gender KPIs which have been set and are measured. These include the number of women at various levels within CAASTRO, the number of female-led CAASTRO sponsored workshops, the number of female CAASTRO visitors, gender targets for speakers and SOC roles in conferences and workshops, the number of females who apply for jobs and those who are short-listed. Gender-based metrics are compiled every 6 months for consideration by the Gender Action Committee.

Despite many innovative ideas surrounding Gender Equality having been incorporated into CAASTRO, the committee was confronted with the fact that overall participation rates within several categories of CAASTRO membership were not representative of the broader community, and were skewed male. Specifically, the number of funded researchers, Partner Investigators (PIs) and Associate Investigators (AIs) are all well below reasonable expectations based on the percentage of women who fill that level within astronomy.

To this end, the committee recommended to the CAASTRO executive that we could improve the representation of women in CAASTRO by:

- asking all CAASTRO nodes to think about how to attract strong female candidates for positions, and to report on their efforts and outcomes in upcoming advertisements
- to put effort in progressing outstanding female Partner Investigator memberships
- to consider whether any female CAASTRO affiliates members could be considered for Associate Investigator status
- to ask Theme Leaders if there are appropriate female researchers to bring in as Partner Investigators, Associate Investigators or Affiliate members emphasizing the lack of women in these roles currently.

The committee also considered the appropriate role for the Gender Action Committee, given that each institution serves as the legal employer for CAASTRO members and has their own regulations. The committee decided that it could best serve CAASTRO by helping improve the prospects for women to navigate the leaky pipeline between PhD and tenured researcher. Initiatives that recommended and in various stages of being implemented include:

- offering programs to CAASTRO members about leadership, focusing on women
- improving and finalising CAASTRO’s diversity policy
- offering a “1 need support now” program for CAASTRO members including students
- holding a CAASTRO Women’s day
- having a CAASTRO Women’s lunch at each node each year
- ensuring that CAASTRO engages with the Women in Astronomy Workshop each year.

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The ARC Mid-Term Review of CAASTRO commented that our gender initiatives were changing the culture of not only CAASTRO but also our member organisations. Currently 90% of professional staff and 17% of research staff have taken up the option of part-time work, and recent gender statistics from the Supernovae Science Conference held in August show a positive impact and improvement on female participation at all levels. Female representation at this conference on the SOC was 34%, the LOC 50%, invited speakers 30%, 48% of contributed talks and 42% of female chairs. CAASTRO also provided free childcare at this conference. Since inception the number of women on the CAASTRO Executive has grown from zero to 14% during 2011-2013, then to its current 38%. CAASTRO now has a female Director, Professor Elaine Sadler. In addition our female Chief Investigators have increased from 16% to 28%.

The Gender Action Committee was very pleased that CAASTRO was awarded an Astronomical Society of Australia’s Pleiades award at the level of Silver in recognition of our Gender Diversity Activities. We were one of only two organisations to receive such a distinction. In 2015, in addition the implementation of these ideas, the Gender action committee will monitor the impact of our work, and continue to update and create new programs in response to our observations.
INVITED TALKS 2014

Major Conferences

*this list does not include public talks or school talks

Invited Talks 2014

(Congresses, workshops, colloquia, projects and collaborations)

Establishing the robustness of cosmological tests of general relativity to dark energy perturbations
Jason Dossert, 223rd Meeting of the American Astronomical Society, USA, January 2014

Cosmology - The next frontier - Big Data or Big Ideas: What is the future of observational cosmology
Brian Schmidt, Is the Universe Necessary, Arizona, USA, January 2014

The State of the world with Nobel Laureates in science
Brian Schmidt, World Economic Forum, Davos, Switzerland, January 2014

The Universe Unveiled - with Chris Lintott
Brian Schmidt, World Economic Forum, Davos, Switzerland, January 2014

Hunting pulsars and fast transients with the SKA
Ewan Barr, Multicore World 2014, New Zealand, February 2014

Large Scale Structure
Tamar Davies, TIARA Winter School on Cosmology, Spain, June 2014

The SAMI Galaxy Survey
Lisa Farghety, 3D2014: Gas and Stars in Galaxies: A multi-wavelength 3D perspective, ESO, Garching, Germany, March 2014

An example of the process of discovery
Brian Schmidt, 6th HOPE Meeting with Nobel Laureates, Tokyo, Japan, March 2014

HI absorption-line science – current results and plans for ASKAP
Elaine Sadler, 7th International PHISCC Workshop - The Challenges of the upcoming HI Surveys, ASTRON, The Netherlands, March 2014

Science with the SKA
Lister Staveley-Smith, 7th International PHISCC Workshop - The Challenges of the upcoming HI Surveys, ASTRON, The Netherlands, March 2014

WALLABY/DINGO kinematic parametrization: a new Bayesian MCMC tilted-ring fitter
Se-Heon Oh, 7th International PHISCC Workshop - The Challenges of the upcoming HI Surveys, ASTRON, The Netherlands, March 2014

OzDES multi-fibre spectroscopy for the Dark Energy Survey: first year operation and results (OzDES first year paper plan)
Fang Yuan, Dark Energy Survey Collaboration Meeting, University of Illinois, USA, May 2014

Galaxy formation with SPHS
Chris Power, nFty cosmology workshop, Madrid, Spain, June 2014

Cosmology: An example of the process of discovery
Brian Schmidt, 64th Lindau Nobel Laureate Meeting, Germany, June 2014

A cosmic census of radio pulsars
Evan Keane, Advancing Astrophysics with the Square Kilometre Array, Giardini Naxos, Italy, June 2014

Connecting the baryons: Multimwavelength data for HI surveys
Martin Meyer, Advancing Astrophysics with the Square Kilometre Array, Giardini Naxos, Italy, June 2014

The astronomical revolution
Brian Schmidt, Euroscience Open Forum 2014, Denmark, June 2014

Different manifestations of neutron stars
Evan Keane, Extreme Astrophysics in an Ever-Changing Universe, Crete, Greece, June 2014

The local velocity field and the Hubble Constant
Jeremy Mould, MIAPP Workshop Extragalactic Distance Scale, Garching, Germany, June 2014

SkyMapper science
Brian Schmidt, Astronomical Society of Australia Annual Scientific Meeting 2014, Sydney, Australia, July 2014

The lives of active galactic nuclei and the evolving Universe
Dr Anna Kapinska, Astronomical Society of Australia Annual Scientific Meeting 2014, Sydney, Australia, July 2014

The SkyMapper Southern Survey
Chris Wolf, European Week of Astronomy and Space Science (EWASS) 2014, Geneva, Switzerland, July 2014

High-time resolution radio astronomy with low-frequency interferometric arrays
Ramnath Bhat, 31st International Union of Radio Science (URSI) General Assembly and Scientific Symposium, Beijing, China, August 2014

Variation in the escape fraction of ionizing photons from galaxies and the redshifted 21-cm power spectrum during reionization
Hansik Kim, Lyman Continuum Leakage and Cosmic Reionization, Stockholm, Sweden, August 2014

SKA and HI lectures (a series of 6 lectures)
Lister Staveley-Smith, SKA Radio Astronomy School, China, August 2014

Locations of peculiar supernovae as a diagnostic of their origins
Fang Yuan, Supernovae in the Local Universe: Celebrating 10,000 days of Supernova 1987A, Coff Harbour, Australia, August 2014

The Zoo of AGNs in the context of clustering and a coherent picture of AGN clustering
Scott Croom, Clustering Measurements of Active Galactic Nuclei, Garching, Germany, September 2014

The SAMI Galaxy Survey
Scott Croom, Galaxy Masses as Constraints of Formation Models, Oxford, UK, September 2014

Gender and diversity in astronomy
Bryan Gaensler, Greater Diversity Forum, Australia, September 2014

Optical and infrared astronomy
James Allen, Looking Up, Looking Down: Interdisciplinary Approaches to Remote Sensing, Image Analysis, and Data Visualisation, Sydney, Australia, September 2014

The fundamental plane and stellar populations of early-type galaxies from low redshift surveys
Matthew Colless, The Life and Times of Galaxies, Utah, USA, September 2014

Ages of type la Supernovae over cosmic time
Mike Childress, Type Ia supernovae: progenitors, explosions, & cosmology conference, Chicago, USA, September 2014

AGN reverberation mapping simulations
Artem Kip, Dark Energy Survey Collaboration Meeting, Brighton, UK, October 2014

The Accelerating Universe
Brian Schmidt, 2014 General Assembly of The International Union of Pure and Applied Physics, Nanyang Technological University, Singapore, November 2014

Cosmology as an example of how science works
Brian Schmidt, 5th International Conference on Cosmology as an example of how science works, Bandung, Indonesia, November 2014

SAMi and HECTOR
Julia Bryant, Astrophotonica Australis, Sydney, Australia, November 2014

The structure of reionization in hierarchical galaxy formation
Hansik Kim, The 6th KiAs Workshop on Cosmology and Structure Formation, South Korea, South Korea, November 2014

Observational dark energy
Brian Schmidt, 10th Asia-Pacific Symposium on Cosmology and Particle Astrophysics, University of Auckland, New Zealand, December 2014

The dark side of astronomy
Brian Schmidt, 10th Asia-Pacific Symposium on Cosmology and Particle Astrophysics, University of Auckland, New Zealand, December 2014

Cosmological constraints on dark energy
Tamara Davis, 10th Asia-Pacific Symposium on Cosmology and Particle Astrophysics, University of Auckland, New Zealand, December 2014

Watching galaxies fall: testing theories of gravity using large galaxy redshift surveys
David Parkinson, Australian Institute of Physics Congress “The Art of Physics”, Australia, December 2014

Everything you wanted to know about diffuse polarisation but were afraid to ask
Emil Lenc, Early Science from Low-Frequency Telescopes, Arizona, USA, December 2014

From earth rotation aperture synthesis to patient rotation computed tomography
Ilana Feain, Edges of Universe Academy of Science Frontiers of Science Meeting, Canberra, Australia, December 2014

What is a decimal plan?
Stuart Wyithe, Edges of Universe Academy of Science Frontiers of Science Meeting, Canberra, Australia, December 2014

The edges of cosmology
Tamara Davies, Edges of Universe Academy of Science Frontiers of Science Meeting, Canberra, Australia, December 2014

Public Lectures 2014

Dark Matter
Astronomy Society of Victoria, Alan Duffy, January 2014

Education, Discovery, and Translation: The Cycle of Science – Part 1
ANU Indonesia Initiative, Bogor, Indonesia, Brian Schmidt, February 2014

Education, Discovery and Translation: The Cycle of Science – Part 2
ANU Indonesia Initiative, Bogor, Indonesia, Brian Schmidt, February 2014

Public event with Anant Agarwal Founder/CEO TedX (MOOC), Brian Schmidt, February 2014

Science Policy
ANU Policy Launch, Canberra, Brian Schmidt, February 2014

Magnets in the Sky
Science Stars of the Future Lecture, Australian Academy of Science, Canberra, Bryan Gaensler, February 2014

The Accelerating Universe
University of Western Sydney, Brian Schmidt, February 2014
The creation of the universe
The Australian museum, Tamara Davis, February 2014

A Nobel Prize Winner’s ponderings on planets, Pinot and prosperity
Rotary Club of Canberra, Canberra, Brian Schmidt, March 2014

Astronomy in Australia: Our part in the big picture
University of Melbourne, Rachel Webster, Melbourne, March 2014

Gender equity within the research sector
International Women’s Day, Australian National University, Canberra, Brian Schmidt, March 2014

Seeing back to the big bang – the Ska telescope’s unlimited potential
National library, Canberra, Brian Schmidt and Brian Boyle, March 2014

Space and wonder
Sunday assembly, Brisbane, Tamara Davis, March 2014

The circle of innovation: Making it work here in Australia
Rotarian talk, Canberra, Brian Schmidt, March 2014

An astronomer’s introduction to databases and sql
ANITA lecture series, Perth, Paul Hancock, April 2014

My life, the universe, and everything about the discovery of cosmic acceleration
Gates Cambridge Scholarship, Brisbane, Brian Schmidt, April 2014

Public lecture
National youth science forum, Brisbane, Tamara Davis, April 2014

Space 2014 TEDxNoosa, Noosa, Tamara Davis, April 2014

The accelerating universe
Charles sturt university, Orange, Brian Schmidt, April 2014

The challenges facing research in australia
Qut Gardens Point campus VC forum address, Brisbane, Brian Schmidt, April 2014

Written in the stars
Qut gardens theatre, Brisbane, Brian Schmidt, April 2014

Murchison Widefield array – big data precursor to the square kilometre array
Scitech planetarium big data week, Perth, Steven Tingay, May 2014

Public lecture
Mandelaun house, Sydney, Bryan Gaensler, May 2014

Public schooling
Australian education union public education celebratory dinner address, Canberra, Brian Schmidt, May 2014

Public lecture and discussion
Women in science breakfast, Brisbane, Tamara Davis, May 2014

Public lecture
Booragoon rotary club, Perth, Steven Tingay, May 2014

Science today for outcomes tomorrow
Defence science and technology organisation strategic context seminar 2014, Canberra, Brian Schmidt, May 2014

The circle of prosperity: Education, science and innovation
Royal society of Victoria, Melbourne, Brian Schmidt, May 2014

What are dark energy and dark matter?
Diurnals society, Melbourne, Chris Blake, May 2014

Neutral hydrogen in the universe
Northern Sydney astronomical society, Sydney, Sarah Reeves, June 2014

Spectroscopy and spectroscopic surveys
Sutherland astronomical society, Sydney, James Allen, June 2014

The accelerating universe
Johannes Gutenberg-universität mainz, Germany, Brian Schmidt, June 2014

Mapping the invisible gas in the milky way using the murchison widefield array
Astronomical society of Western australia, Perth, Paul Hancock, July 2014

Public lecture
Neighbourhood fellowship, Canberra, Brian Schmidt, July 2014

Science and society
Kenneth myer lecture, National library of australia, Canberra (also filmed for abc big ideas program), Brian Schmidt, July 2014

Square kilometre array
Linux users Victoria, Melbourne, Ewan Barr, July 2014

The path to winning a Nobel prize
China scholarship council program, Canberra, Brian Schmidt, July 2014

A tour of the universe
Imperial college London, UK, Katie Mack, August 2014

A tour of the universe
World science fiction convention, UK, Katie Mack, August 2014

Creating the universe in a computer
Stars in the Yarra ranges, National science week, vic, Chris Power, August 2014

Galaxy information
Stars in the Yarra ranges, National science week, Vic, Karl Glazebrook, August 2014

Pulsars and fast radio bursts
Stars in the Yarra ranges, National science week, Vic, Emily Petroff, August 2014

The square kilometre array telescope
Stars in the Yarra ranges, National science week, Vic, Ewan Barr, August 2014

Type 1A supernovae and cosmology
Stars in the Yarra ranges, National science week, Vic, Syed Uddin, August 2014

The cosmic microwave background
Stars in the Yarra ranges, National science week, Vic, Pietro Procopio, August 2014

Paving the way with the MWA
Scitech planetarium, Perth, Steven Tingay, August 2014

When does science matter?
Public lecture, The Australian national university, Canberra, Brian Schmidt, August 2014

Public lecture
Astronomical group of WA, Perth, Chris power, August 2014

Public lecture
Uluru astronomy weekend, NT, Rachel Webster, August 2014

Public lecture
Uluru astronomy weekend, NT, Steven Tingay, August 2014

The accelerating universe
University of Launceston, Hobart, Brian Schmidt, August 2014

The accelerating universe
University of Tasmania, Sandy Bay, Brian Schmidt, August 2014

The history of physics and astronomy in Australia
Science at the shine dome, Canberra, Brian Schmidt, August 2014

What will you do when your doctorate is done?
PhD to present: a day dedicated to the career pathways of those who have gone before you, Australian national university, Canberra, Brian Schmidt, August 2014

brief remarks on career, future of astronomy, role of GMT
Giant Magellan telescope dinner, USA, Brian Schmidt, September 2014

In search of the ultimate fate of the universe: Some reflections on my life as a postdoc managing an international team, and trying to balance career and family
University of new south wales, Brian Schmidt, September 2014

Public talk on a career in science
The science career carousel, kararra, WA, Alan Duffy, September 2014

Science and society
National library of Australia, Melbourne, Brian Schmidt, September 2014

The universe as we know it
St Paul’s college, The university of Sydney, Brian Schmidt, September 2014

Universe from beginning to end: Learn everything we know about the universe from its beginning to its end and the bits in between
Mt Stromlo observatory public observing nights, ACT, Brian Schmidt, September 2014

A starry night
Milroy Observatory, ACT, Brian Schmidt, Fred Watson and David Malin, October 2014

A strange world! Interactive role-playing activity to decipher the universe from observations
University from A-Z
Mt Stromlo and Regional Partnership School student activities and presentation, ACT, Brian Schmidt, October 2014

Bright things in the night sky
Starfest 50th birthday celebrations & open day
Children’s’ talk, Siding springs observatory, ACT, Brian Schmidt, October 2014

The big questions: How researchers are unlocking the mysteries of the universe
Starfest, Siding Springs observatory, 50th birthday celebrations and open day, ACT, Brian Schmidt, October 2014

How a normal person helped discover 70% of the universe:
Or, a Nobel Prize winner’s guide to leadership
Attorney-General’s department & ministry of the arts ‘talking heads’ series address, Canberra, Brian Schmidt, October 2014

Leading a revolution in radio astronomy with the askap and MWA
Western Sydney amateur astronomy group, Sydney, Emil Lenc, October 2014

Spinning the cosmic web in a supercomputer
Scitech horizon dome, Perth, Chris power and Paul Scott-Taylor, October 2014

The dark side of astronomy
University of Auckland, New Zealand, Brian Schmidt and Tamara Davis, October 2014

The path to winning a Nobel prize
ANU edge 2014 China scholarship council programme, Canberra, Brian Schmidt, October 2014

Examining gas from galaxies billions of years old
Inspiring science, Ultimo community centre, Sydney, Vanessa Moss, November 2014

Public lecture
Elemental at Melbourne planetarium, Melbourne, Alan Duffy, November 2014

It’s a wonderful world
Woodford folk festival – green forum, Queensland, Tamara Davis with Ian lowe, December 2014

The dark side
Woodford folk festival, Queensland, Tamara Davis, December 2014
A Tour of the Universe
Swindon University, Melbourne, Katie Mack, December 2014

Cosmology
Australia/New Zealand Physics Summer School “Frontiers in Physics”, Australian National University, Canberra, Brian Schmidt, December 2014

Public talk about SKA
University of the 3rd Age, Science and Technology Division, Sydney, Anne Green, December 2014

The Dark Side of Astronomy
Auckland, New Zealand, Brian Schmidt, December 2014

Other Presentations 2014
Conferences, workshops, colloquia, projects and collaborations

Infering Ejected Masses of Type Ia Supernovae from Nearby Supernova Factory Data

SN 2012fi: A Type Ia Supernova with Extreme High Velocity Features and Stratified Eject
Mike Christidis, 223rd Meeting of the American Astronomical Society, Washington DC, USA, January 2014

Great Debate: Parallel Realities: Probing Fundamental Physics (PANEL)
Brian Schmidt, Is the Universe Necessary, Arizona, USA, January 2014

Polarisation with the Murchison Widefield Array (There and Back Again)
Emil Lenc, SKA Science Assessment Workshop – Magnetism, Manchester, UK, January 2014

Curtin Update

Radio Polariometry and the Magnetic Universe
Bryan Gaensler, University of Toronto, Colloquia, Canada, January 2014

The SAMI Galaxy Survey: First Results
Lisa Faggarty, AAO Colloquium, Sydney, Australia, February 2014

Constant vs. variable winds: effect on high-z galaxies
Edoardo Tesari, ANITA 2014 Workshop and Informatics School, Sydney, Australia, February 2014

How should we observe the Epoch of Reionisation?
Cath Trott, ANITA 2014 Workshop and Informatics School, Sydney, Australia, February 2014

New Constraints on f(R) gravity using ISiTGR and the WiggleZ power spectrum
Jason Dossett, ANITA 2014 Workshop and Informatics School, Sydney, Australia, February 2014

Run N-body school
Chris Power, ANITA 2014 Workshop and Informatics School, Sydney, Australia, February 2014

The WIZ-COLA simulation: many many simulations for the WiggleZ survey
Jun Koda, ANITA 2014 Workshop and Informatics School, Sydney, Australia, February 2014

Supernova Science in Australia
Mike Christidis, Gaia-PESSTO Workshop Belfast, Ireland, February 2014

Radio Polariometry and the Magnetic Universe
Bryan Gaensler, NOVA Lecture, Leiden University, The Netherlands, February 2014

Radio Polariometry and the Magnetic Universe
Bryan Gaensler, NOVA Lecture, Radboud University Nijmegen, Groningen, The Netherlands, February 2014

Radio Polariometry and the Magnetic Universe
Bryan Gaensler, NOVA Lecture, University of Amsterdam, The Netherlands, February 2014

Radio Polariometry and the Magnetic Universe
Bryan Gaensler, NOVA Lecture, University of Amsterdam, The Netherlands, February 2014

First Galaxies and DRAGONS
Alan Duffty, Seminar, CSIRO; University of Queensland; University of Sydney, Australia, February 2014

Progenitors of Type Ia Supernovae
Mike Christidis, Southampton University, UK, February 2014

Tracing the cosmic web with velocity tensor
Weiguang Cui, Tracing the Cosmic Web, Leiden, The Netherlands, February 2014

Searching for the Synchrotron Cosmic Web with the Murchison Widefield Array
Bryan Gaensler, Tracing the Cosmic Web, Leiden, The Netherlands, February 2014

The Fundamental Plane in 3D from 6dF and SAMI
Matthew Colless, 3D2014: Gas and Stars in Galaxies: A multi-wavelength 3D perspective, ESO, Garching , Germany, March 2014

The Fundamental and Mass Planes for three nearby clusters from the SAMI Pilot Survey
Nic Scott, 3D2014: Gas and Stars in Galaxies: A multi-wavelength 3D perspective, ESO, Garching, Germany, March 2014

Large surveys for 21 cm-H absorption
Elaine Sadler, 3D2014: Gas and Stars in Galaxies: A multi-wavelength 3D perspective, ESO, Garching, Germany, March 2014

Signatures of quenching in SAMI cluster galaxies

Angular Momentum in the Era of the SKA
Danail Gheznev, 7th International PHISCC Workshop - The Challenges of the Upcoming HI Surveys, ASTRON, The Netherlands, March 2014

Cosmology with 4MOST
Chris Blake, AAO Workshop on science with 4MOST spectrograph, Australia, March 2014

A large number of fast cosmological simulations for the revised WiggleZ BAO measurement
Jun Koda, Kavli Institute for the Physics and Mathematics of the Universe, Tokyo, Japan, March 2014

Plenary panel: Time to rethink: Learning for a changing world
Brian Schmidt, Science World Summit 2014, Belgium, March 2014

Advanced MWA primary beam models
Randall Wayth, SKA Calibration and Imaging Workshop (CALIMI) 2014, Kiama, Australia, March 2014

Polarisation with the Murchison Widefield Array (There and Back Again)
Emil Lenc, SKA Calibration and Imaging Workshop (CALIMI) 2014, Kiama, Australia, March 2014

4MOST/WAVES, eROSITA and CAASTRO-2
Bryan Gaensler, The WAVES survey on 4MOST, Sydney, Australia, March 2014

MWA Polarisation for Transient Astronomers
Emil Lenc, Transient Busy Week at Sydney University, Sydney, Australia, March 2014

DARK Lizards Informal workshop discussing the future of simulation work on alternative gravity models
Jason Dossett, Alternative Gravity Workshop, Brisbane, Australia, April 2014

Detector array cosmetics
Fang Yuan, SkyMapper: Everything you need to know to use the Terabytes, Australia, April 2014

Detector array cosmetics
Fang Yuan, SkyMapper: Everything you need to know to use the Terabytes, Australia, April 2014

Parke: pulsars and radio transients
Matthew Bailes, SkyMapper: Everything you need to know to use the Terabytes, Australia, April 2014

SkyMapper supernova survey
Richard Scalzo, SkyMapper: Everything you need to know to use the Terabytes, Australia, April 2014

SkyMapper ToO programmes
Fang Yuan, SkyMapper: Everything you need to know to use the Terabytes, Australia, April 2014

System performance & stats, eROSITA, Photometric redshifts
Chris Blake, SkyMapper: Everything you need to know to use the Terabytes, Australia, April 2014

Dark matter cores in dwarf galaxies
Se-Heon Oh, CAASTRO PAM, Perth, May 2014

Fast Radio Bursts
Evan Keane, Curtin University/University of Western Australia Colloquia, Australia, May 2014

2d Lens
Tamara Davis, Dark Energy Survey Collaboration Meeting, University of Illinois, USA, May 2014

Baryon acoustic peak reconstruction in WiggleZ
Chris Blake, Dark Energy Survey Collaboration Meeting, University of Illinois, USA, May 2014

OzDES Reverberation Mapping Campaign Simulations
Tamara Davis, Dark Energy Survey Collaboration Meeting, University of Illinois, USA, May 2014

OzDES Global redshift Catalog
Syed Uddin, Dark Energy Survey Collaboration Meeting, University of Illinois, USA, May 2014

OzDES Global redshift Catalog
Syed Uddin, Dark Energy Survey Collaboration Meeting, University of Illinois, USA, May 2014

Absorption line indices
Jeremy Mould, OzDES Busy Week, Ballina, Australia, May 2014

OzDES Global redshift Catalog
Syed Uddin, OzDES Busy Week, Ballina, Australia, May 2014

Dropping Targets in OzDES
Conor O’Neill, OzDES Busy Week, Ballina, Australia, May 2014

Peculiar velocities and Lensing
Tamara Davis, OzDES Busy Week, Ballina, Australia, May 2014

Practical Statistics for Astronomers
Tamara Davis, OzDES Busy Week, Ballina, Australia, May 2014

Redshfitting pitfalls
Tamara Davis, OzDES Busy Week, Ballina, Australia, May 2014

Improving distance measurements to z=1 by reconstructing the WiggleZ Dark Energy Survey

Baryonic acoustic feature
Reconstructing the WiggleZ Dark Energy Survey

Space Situational Awareness with the Murchison Widefield Array
Benjamin McKinley, 2nd Australian Workshop on Space Situational Awareness, Canberra, Australia, June 2014

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MWA and AST3 Collaboration opportunities
Paul Hancock, 3rd international collaboration meeting on Antarctic Survey Telescopes, Nanjing, China, June 2014

Cosmology with Fast Radio Bursts
Cathryn Trott, Advancing Astrophysics with the Square Kilometre Array, Giardini Naxos, Italy, June 2014

Broadband polarimetry with the Square Kilometre Array
Bryan Gaensler, Advancing Astrophysics with the Square Kilometre Array, Giardini Naxos, Italy, June 2014

The Intergalactic medium and the Cosmic Web
Attila Popping, Advancing Astrophysics with the Square Kilometre Array, Giardini Naxos, Italy, June 2014

HI Stacking & the Tully-Fisher Relation
Matthew Colless, SAMI-Sydney AAO Integral Field Spectrograph, Melbourne, Australia, August 2014

The hosts of hybrids: How do peculiar radio galaxies shake our unification schemes?
Anna Kapinska, Powerful AGN and their Host Galaxies Across Cosmic Time, Port Douglas, Australia, June 2014

Data reduction update
James Allen, SAMI Busy Week, Sydney, Australia, June 2014

Multiple Component Spectral Line Fitting
Rebecca McElroy, SAMI Busy Week, Sydney, Australia, June 2014

Star Formation Gradients and Galaxy Environments
Adam Schaefer, SAMI Busy Week, Sydney, Australia, June 2014

The MWA All-Sky Survey and its first science
Anna Kapinska, SPARCS (SKA Pathfinders Radio Continuum Survey) 2014 meeting, Catania, Italy, June 2014

Infall and outflow in the halo of the Milky Way
Vanessa Moss, Astronomical Society of Australia Annual Scientific Meeting, Sydney, Australia, July 2014

Low-frequency radio emission from ultracool dwarfs
Cleo Loi, Astronomical Society of Australia Annual Scientific Meeting, Sydney, Australia, July 2014

SN 2012fr and High-Velocity Features in Type Ia Supernovae
Mike Childress, Astronomical Society of Australia Annual Scientific Meeting, Sydney, Australia, July 2014

Is the best distance indicator a tape measure?
Jeremy Mould, Astronomical Society of Australia Annual Scientific Meeting, Sydney, Australia, July 2014

The first real-time FRB
Emily Petroff, Astronomical Society of Australia Annual Scientific Meeting, Sydney, Australia, July 2014

Modelling of the Spectral Energy Distribution of Fornax A: Leptonic and Hadronic Production of High Energy Emission from the Radio Lobes
Benjamin McKinley, Astronomical Society of Australia Annual Scientific Meeting, Sydney, Australia, July 2014

Origin of cosmic chemical abundances
Edoardo Tescari, Cambridge Regional IAU Meeting, Spain, July 2014

CHyperXI: Core Simulation of the Formation and Evolution of a Star-cluster

A pursuit of transient radio sources
Manisha Celik, Women in Astronomy Workshop, ANU Canberra, August 2014

Cosmological constraints on dark energy
Tomasso Squartini, CoEPP/CAASTRO Joint Workshop 2014, Australia, September 2014

Dark Matter Halos and Cosmic Evolution
Katie Mack, CoEPP/CAASTRO Joint Workshop 2014, Australia, September 2014

The impact of space activities on science
Euan Bchar, European Space Agency (ESA) 50 Years Significant Event, Geneva, Switzerland, September 2014

Detecting Neutral Hydrogen in really high redshift galaxies with the MWA
Randall Wayth, ICRAR-CON, Perth, Australia, September 2014

The Fast Radio Burst Hunter
Steven Trembly, ICRAR-CON, Perth, Australia, September 2014

The simulated cluster project
Weiguang Cui, ICRAR-CON, Perth, Australia, September 2014

Black Holes meet Cancer Therapy: Supernovae meets Diabetes
Ilana Feain, Ingham Institute, Sydney, Australia, September 2014

The neutral hydrogen content of galaxies in the GAMA survey: an HI stacking experiment
Attila Popping, The role of Hydrogen in the Evolution of Galaxies, Malaysia, September 2014

The SAMI Galaxy Survey: the origin of gas in galaxies
Julia Bryant, The role of Hydrogen in the Evolution of Galaxies, Malaysia, September 2014

The Range of Ejected Masses in Type Ia Supernovae
Richard Scalzo, Type Ia supernovae: progenitors, explosions and cosmology conference, Chicago USA, September 2014

Polarisation with the Extended MWA
Emil Lenc, Extended Capabilities for the Murchison Widefield Array, Sydney, Australia, October 2014

Searching for the Synchrotron Cosmic Web with the Murchison Widefield Array
Bryan Gaensler, Extended Capabilities for the Murchison Widefield Array, Sydney, Australia, October 2014

Merging the Wider EoR Signal Using the Moon and an Extended MWA
Ben McKinley, Extended Capabilities for the Murchison Widefield Array, Sydney, Australia, October 2014
Options for GLEAM2
Extended MWA capabilities for transients and variability
Randall Wayth, Extended Capabilities for the Murchison Widefield Array, Sydney, Australia, October 2014

Science case for higher time resolution than the current EoR signal
Ramesh Bhat, Extended Capabilities for the Murchison Widefield Array, Sydney, Australia, October 2014

Workshop summary
Randall Wayth, Extended Capabilities for the Murchison Widefield Array, Sydney, Australia, October 2014

Extended MWA capabilities for transients and variability
Tara Murphy, Extended Capabilities for the Murchison Widefield Array, Sydney, Australia, October 2014

Options for GLEAM2
Lister Staveley-Smith, Extended Capabilities for the Murchison Widefield Array, Sydney, Australia, October 2014

Complementary infrared surveys
Jeremy Mould, Large Synoptic Survey Telescope meeting, Melbourne, Australia, October 2014

Young and Frustrated: Studying GPS/CSR sources with the MWA
Joe Callingham, MWA Radio Galaxy Workshop, Perth, Australia, October 2014

Real-time discovery of Fast Radio Bursts
Emily Petroff, Transient Phenomena in Astronomy and Astrophysics, Washington, USA, October 2014

The Demography of Fast Radio Bursts from Cosmological Simulations
Bryan Gaensler, CAASTRO Annual Retreat 2014, Australia, November 2014

Theoretical Modelling of the WiggloZ Galaxy Power Spectrum
Carsten Adame, CAASTRO Annual Retreat 2014, Australia, November 2014

CAASTRO Research: The Evolving Universe Overview
Tamar Davis, CAASTRO Annual Retreat 2014, Australia, November 2014

Background and Noise Estimation
Paul Hancock, CAASTRO Annual Retreat 2014, Australia, November 2014

BIGHORNs: Broadband Instrument for the Global Hydrogen Reionisation Signal
Marcin Sokolowski, CAASTRO Annual Retreat 2014, Australia, November 2014

Comparing the 2MTF and 6dFGS Peculiar Velocity Surveys to models from redshift surveys
Christopher Springob, CAASTRO Annual Retreat 2014, Australia, November 2014

How do you do Slow transients?
Tara Murphy, CAASTRO Annual Retreat 2014, Australia, November 2014

Outreach and Education in CAASTRO
Steven Tingay, CAASTRO Annual Retreat 2014, Australia, November 2014

CAASTRO Research: The Dynamic Universe Overview
Evan Keane, CAASTRO Annual Retreat 2014, Australia, November 2014

How do you do fast transients?
Evan Keane, CAASTRO Annual Retreat 2014, Australia, November 2014

Supernovae and FRBs
Evan Keane, CAASTRO Annual Retreat 2014, Australia, November 2014

SUPERB
Evan Keane, CAASTRO Annual Retreat 2014, Australia, November 2014

The first real-time fast radio burst detection: polarization and multi-wavelength follow-up of a radio transient
Emily Petroff, CAASTRO Annual Retreat 2014, Australia, November 2014

Taking the pulse of the cosmos with Molonglo
Chris Flynn, CAASTRO Annual Retreat 2014, Australia, November 2014

The Molonglo pulsar timing programme
Fabian Jonkowski, CAASTRO Annual Retreat 2014, Australia, November 2014

The SAMI Galaxy Survey: finding and classifying kinematically perturbed galaxies
Jessica Bloom, CAASTRO Annual Retreat 2014, Australia, November 2014

A Novel Data Archive for SAMI
Irkis Konstantopoulos, CAASTRO Annual Retreat 2014, Australia, November 2014

The SKA view of Gamma-ray Bursts
David Burton, Italian Scientists Down Under, Italian Embassy, Canberra, Australia, November 2014

Using the FAST Radio Telescope to Detect Quasar HI Regions during the EoR
Tristan Reynolds, Mt Stromlo Christmas Seminars, Australia, November 2014

Large Scale Pulsar Timing
Fabian Jankowski, The 2014 Orange Pulsar meeting, Melbourne, Australia, November 2014

Searching for fast radio bursts in pulsar surveys
Emily Petroff, The 2014 Orange Pulsar meeting, Melbourne, Australia, November 2014

SUPERB
Evan Keane, The 2014 Orange Pulsar meeting, Melbourne, Australia, November 2014

High time resolution science with the Murchison Widefield Array
Ramesh Path, The 2014 Orange Pulsar meeting, Melbourne, Australia, November 2014

Galaxy haloes at high redshift: outflow vs pre-enrichment

Environmental Effects in Overdense Regions
Lister Staveley-Smith, The Periphery of Disks, Sydney, Australia, November 2014

Inferring Explosion Properties of Type I Supernovae
Richard Calzo, Australian Frontiers of Science, CBR Australia, December 2014

Panel discussion and interview with Dr John O’Sullivan
Brian Schmidt, Australian Frontiers of Science, Canberra, Australia, December 2014
The Cosmological HI Power Spectrum Estimator
Cathryn Trott, Early Science for Low Frequency Telescopes, Tempe, Arizona, USA, December 2014

Modelling the Spectral Energy Distribution of Fornax A
Ben McKinley, Early Science for Low Frequency Telescopes, Tempe, Arizona, USA, December 2014

Processing MWA EOR Data with the RTS
Bart Pindor, Early Science for Low Frequency Telescopes, Tempe, Arizona, USA, December 2014

Waves in the sky: Probing the ionosphere with the Murchison Widefield Array
Cleo Loi, Early Science for Low Frequency Telescopes, Tempe, Arizona, USA, December 2014

Young and Frustrated: Studying GPS/CSS sources with the MWA
Joe Callingham, Early Science for Low Frequency Telescopes, Tempe, Arizona, USA, December 2014

Radio Galaxy Zoo – Part II: The users
Anna Kapinska, EMU/POSSUM/GALFACTS meeting 2014, Australia, December 2014

Polarimetry with ASKAP and BETA (II) - A secondee’s perspective
Emil Lenc, EMU/POSSUM/GALFACTS meeting 2014, Australia, December 2014

Positional Updating and Matching Algorithm (PUMA)
Jack Line, Early Science for Low Frequency Telescopes, Tempe, Arizona, USA, December 2014

SUPERB
Evan Keane, FRB Workshop, Melbourne, Australia, December 2014

The first Real-time FRB
Chris Blake, Frontiers of Science, Australia, December 2014

Polarisation Update
Emil Lenc, Early Science for Low Frequency Telescopes, Tempe, Arizona, USA, December 2014

The Brilliance of GLEAM: NGC253 and the Sculptor Group
Anna Kapinska, Early Science for Low Frequency Telescopes, Tempe, Arizona, USA, December 2014

The MWA Exoplanet Survey
Tara Murphy, Early Science for Low Frequency Telescopes, Tempe, Arizona, USA, December 2014

Probing Hα: Aperture Correction with SAMI
Samuel Richards, SAMI Busy Week, Melbourne, Australia, December 2014

Gas alignment in galaxies
Julia Bryant, SAMI Busy Week, Melbourne, Australia, December 2014

The True Nature of offset AGN
James Allen, SAMI Busy Week, Melbourne, Australia, December 2014

Everything you wanted to know about the Universe but were afraid to ask

International Visitors to CAASTRO in 2014

Simona Bekeraite
Leibniz Institute for Astrophysics Potsdam, Germany

Jamie Bolton
University of Nottingham, UK

Steve Curran
University of Victoria, New Zealand

Roger Davies
University of Oxford, UK

Julius Donnert
Istituto di Radioastronomia, Bologna, Italy

Richard Easther
University of Auckland, New Zealand

Bjorn Emsont
CSIC-NTO (Centro de Astrobiologica), Madrid, Spain

Stephen Fine
University of Western Cape in South Africa, South Africa

Martha Haynes
Cornell University, USA

George Heald
ASTRON, Amsterdam, The Netherlands

John Hillier
University of Pittsburgh, USA

Assaf Horesh
Weizmann Institute of Science, Israel

Jeremy Howard
University of San Francisco, USA

Garth Illingworth
University of California Observatories, USA

Hub Intema
National Radio Astronomy Observatory, New Mexico, USA

David Kaplan
University of Wisconsin, USA

Wolfgang Kerzendorf
University of Toronto, Canada

Robert Kirschner
Harvard-Smithsonian Center for Astrophysics, USA, USA

Roland Kotes
National Research Council, Canada

Tom Landecker
Dominion Radio Astrophysical Observatory, Penticton, Canada

Bruno Leibundgut
ESO Office for Science, Germany

Nicholas Mahany
Franklin & Marshall College, USA

Raffaella Margotti
Harvard-Smithsonian Center for Astrophysics, USA

Paolo Mazzali
Astrophysics Research Institute, John Moores University, Liverpool, UK

Fulvio Mella
University of Arizona, USA

Kunal Mooley
California Institute of Technology, USA

Cherry Ng
Max Planck Institute for Radio Astronomy, Germany

Ken’ichi Nomoto
University of Tokyo, Japan

Elena Pian
INAF Institute of Space Astrophysics and Cosmic Physics, Italy

Amrita Purkayastha
Istituto di Radioastronomia, Bologna, Italy

Kevin Schawinski
ETH Zurich, Switzerland

Volker Springel
Heidelberg Institute for Theoretical Studies, Germany

Ravi Subrahmanyan
Raman Research Institute, India

Nathan Tehrani
West Virginia University, USA

Caterina Tiburzi
Osservatorio Astronomico di Cagliari, Italy

Tony Willis
Dominion Radio Astrophysical Observatory, Penticton, Canada

Tim de Zeeuw
European Southern Observatory, Garching, Germany
Visits to overseas laboratories and facilities in 2014

Martin Bell
Arizona State University, USA

Joe Callingham
Arizona State University, USA

Bryan Gaensler
Arizona State University, USA

Jack Line
Arizona State University, USA

Cleo Loi
Arizona State University, USA

Ben McKinley
Arizona State University, USA

Tara Murphy
Arizona State University, USA

Pietro ProcoPIO
Arizona State University, USA

Brian Schmidt
Arizona State University, USA

Rachel Webster
Arizona State University, USA

Danail Obreschkow
ASTRON, The Netherlands

Se-Heon Oh
ASTRON, The Netherlands

Lister Staveley-Smith
ASTRON, The Netherlands

Attilla Popping
ASTRON, The Netherlands

James Allison
ASTRON, The Netherlands

Ewan Barr
Auckland University of Technology, New Zealand

Willem van Straten
Auckland University of Technology, New Zealand

Matthew Baines
Califor nia Institute of Technology, USA

Brian Schmidt
California Institute of Technology, USA

Bryan Gaensler
Canadian Institute for Theoretical Astrophysics, Toronto, Canada

Richard Scalo
Carnegie Observatories in Pasadena, USA

Anna Kapinska
Catania Observatory, Catania, Italy

Stuart Wyithe
Catania Observatory, Catania, Italy

Jonghwan Rhee
Center for Astronomy & Astrophysics, Shanghai Jiao Tong University, China

Lister Staveley-Smith
Center for Astronomy & Astrophysics, Shanghai Jiao Tong University, China

Bryan Gaensler
Centre d’Etudes de Saclay, Paris, France

Attilla Popping
Columbia University, New York, USA

Brian Schmidt
Dark Cosmology Centre, The Niels Bohr Institute, Denmark

Bryan Gaensler
Dunlap Institute for Astronomy and Astrophysics, Toronto, Canada

James Allen
European Southern Observatory, Garching, Germany

James Allison
University of Oxford, UK

Ramesh Bhat
Giant Metawave Radio Telescope, India

Ramesh Bhat
International Union of Radio Science, Beijing, China

Chris Blake
University of California (Berkeley), USA

Chris Blake
University of Canterbury, New Zealand

Chris Blake
University of Illinois, USA

Davide Burton
University of Trieste – INAF Trieste Astronomical Observatory, Italy

Mike Childress
Keck Telescope, Hawai’i, USA

Mike Childress
Queen’s University Belfast, Ireland

Mike Childress
Southampton University, UK

Mike Childress
University of Hawai’i, USA

Matthew Colless
European Southern Observatory, Garching, Germany

Weiguang Cui
Leiden University, The Netherlands

Tamara Davis
Institute of Astronomy and Astrophysics, Taiwan

Tamara Davis
Lawrence Berkeley National Laboratory, USA

Tamara Davis
University of Auckland, New Zealand

Tamara Davis
University of Hawai’i, USA

Tamara Davis
University of Illinois, USA

Alan Duffy
University of Manchester, UK

Alan Duffy
University of Nottingham, UK

Lisa Fogarty
European Southern Observatory, Garching, Germany

Lisa Fogarty
Gemini South, La Serena, Chile

Lisa Fogarty
Institute of Astronomy, Cambridge, UK

Lisa Fogarty
University of Oxford, UK

Bryan Gaensler
École Normale Supérieure, Paris, France

Bryan Gaensler
Institut d’Astrophysique Spatiale, Paris, France

Bryan Gaensler
Leiden University, The Netherlands

Bryan Gaensler
Observatoire de Paris, Paris, France

Bryan Gaensler
Radboud University Nijmegen, Nijmegen, The Netherlands

Bryan Gaensler
Square Kilometre Array Office, Jodrell Bank, UK

Bryan Gaensler
Université Paris Diderot, Paris, France

Bryan Gaensler
Université Paris-Diderot, Paris, France

Bryan Gaensler
University of Amsterdam, The Netherlands

Bryan Gaensler
University of Groningen, The Netherlands

Anna Kapinska
Institute of Cosmology and Gravitation, University of Portsmouth, UK

Anna Kapinska
Texas Tech University, USA

Antonios Katsianis
Laboratoire d’Astrophysique de Marseille, Université d’Aix-Marseille, France

Eyal Kazin
Kavli Institute for the Physics and Mathematics of the Universe, Tokyo, Japan

Eyal Kazin
University of Opo, Norway

Evan Keane
SKA Project Office, Manchester, Jodrell Bank, UK

Hansik Kim
Korea Institute for Advanced Study, South Korea

Hansik Kim
Kyungpook National University, South Korea

Anthea King
Royal Observatory, University of Edinburgh, UK

Anthea King
University of St Andrews, UK

Anthea King
University of Sussex, UK

Jun Koda
Kavli Institute for the Physics and Mathematics of the Universe, Tokyo, Japan

Emil Lenc
SKA Project Office, Manchester, Jodrell Bank, UK

Emil Lenc
University of California (Berkeley), USA

Jack Line
Penn State University, USA

Jack Line
University of California (Berkeley), USA

Jean-Pierre Macquart
SKA Project Office, Manchester, Jodrell Bank, UK

Felipe Marín
Fundación Centro de Estudios de Física del Cosmos de Aragón, Spain

Felipe Marín
Max Planck Institute for Astronomy, Heidelberg, Germany

Felipe Marín
University of Bologna, Italy

Jeremy Mould
Munich Institute for Astro- and Particle Physics, Germany

Se-Heon Oh
Universidad Autónoma de Madrid, Spain
SkyMapper Workshop

In April 2014, almost fifty people came together for three days in the Commonwealth Solar Observatory Building at Mt Stromlo outside Canberra, to attend a CAASTRO workshop on the SkyMapper telescope. There has been high expectation of SkyMapper for several years, however a diverse range of challenges had delayed it. The telescope started its long-awaited survey only weeks before the workshop, so it was a good time to bring together the builders and users of the survey.

Starting the workshop, the then CAASTRO Director, Bryan Gaensler, reminded attendees of SkyMapper’s cornerstone role in CAASTRO and its synergy with a host of other Australian all-sky projects. Brian Schmidt ran through SkyMapper’s history, which brought back memories of bushfires, broken filters and ladybug invasions. Christian Wolf updated attendees on the current plan and progress with the telescope, now commissioned, and the survey strategy, the progress of projects, and updated science priorities.

The afternoon was devoted to technical and performance aspects of SkyMapper, including ideas for maximising the quality of data distributed to the community. The highlight of this session was a demonstration by Simon Murphy (formerly ANU, now at the University of Heidelberg) of how the SkyMapper data will be accessed through the Virtual Observatory. This facility now offers powerful tools.

On the morning of the second day, SkyMapper’s work on variable phenomena was discussed, including the supernova survey, target-of-opportunity alerts, GRBs, FRBs, and the potential to look for gravitational waves. Brad Tucker (ANU) introduced a session on SkyMapper’s support for the extended mission of the Kepler Space Telescope, the world’s most powerful tool for the study of micro variability. This session had a focus on initiatives for exploiting synergies between SkyMapper and Kepler.

The afternoon was devoted to the subject of galaxy evolution, with a focus on a holistic approach to understanding all the components that contribute to a galaxy’s evolution. This included presentations on active nuclei, the fate of gas in light of feedback, and the complications introduced by dust. The session also covered multi-wavelength approaches, as well as combining SkyMapper observations with data from the Australian SKA Pathfinder, spectroscopic instruments, and from the German-Russian eROSITA mission.

The final day of the workshop brought the focus back to one of SkyMapper’s core strengths: the mapping of the Milky Way. A report on the early discovery of the most metal-poor and pristine star known in the Universe found in early observations was presented. The SkyMapper Executive Committee to meet for the first time. Overall, the workshop made clear that the community’s commitment to SkyMapper is strong and that there is a growing interest in the science opportunities that it offers.

CAASTRO hosted a number of interesting, well attended and stimulating workshops during 2014.

Pietro Procopio
University of California (Berkeley), USA

Brian Schmidt
University of Auckland, New Zealand

Mayuri Rao
Raman Research Institute, Bangalore, India

Brian Schmidt
University of Southampton, UK

Jonghwan Rhee
Korean Astronomy and Space Science Institute, Korea

Brian Schmidt
University of Toronto, Canada

Jonghwan Rhee
National Astronomical Observatories, Chinese Academy of Sciences, China

Nic Scott
European Southern Observatory, Garching, Germany

Jonghwan Rhee
Shanghai Astronomical Observatory, China

Ivo Seitenzahl
University of Illinois at Urbana-Champaign, USA

Jennifer Riding
Penn State University, USA

Lister Staveley-Smith
National Astronomical Observatories Chinese Academy of Sciences, China

Jennifer Riding
University of California (Berkeley), USA

Lister Staveley-Smith
Shanghai Astronomical Observatory, China

Ashley Rulter
University of Illinois at Urbana-Champaign, USA

Lister Staveley-Smith
SKA Project Office, Manchester, Jodrell Bank, UK

Elaine Sadler
European Southern Observatory, Garching, Germany

Lister Staveley-Smith
University of Waterloo, Canada

Richard Scalzo
Harvard-Smithsonian Center for Astrophysics, USA

Edoardo Tescari
International Centre for Theoretical Physics, Trieste, Italy

Richard Scalzo
Stony Brook University, USA

Edoardo Tescari
Istituto di Astrofisica, Ponticia Universidad Católica de Chile, Chile

Richard Scalzo
University of Pittsburgh, USA

Edoardo Tescari
University of Trieste – INAF Trieste Astronomical Observatory, Italy

Adam Schaefer
Durham University, Durham, UK

Cath Trott
SKA Project Office, Manchester, Jodrell Bank, UK

Brian Schmidt
Institut Teknologi Bandung, Indonesia

Syed Uddin
University of Illinois, USA

Brian Schmidt
Johannes Gutenberg–Universität Mainz, Germany

Rachel Webster
University of Auckland – INAF Trieste Astronomical Observatory, Italy

Brian Schmidt
Kapteyn Astronomical Institute, Groningen, The Netherlands

Cath Trott
SKA Project Office, Manchester, Jodrell Bank, UK

Brian Schmidt
Munich Institute of Astro- and Particle Physics, Germany

Rachel Webster
University of Chicago (Berkeley), USA

Brian Schmidt
MiraiKan National Museum of Emerging Science and Innovation, Japan

Chris Wolf
European Southern Observatory, Garching, Germany

Brian Schmidt
Nanyang Technological University, Singapore

Max-Planck-Institut für Astronomie, Heidelberg, Germany

Brian Schmidt
Queen’s University Belfast, Ireland

Chris Wolf
University of Auckland, New Zealand

Brian Schmidt
Queen’s University Kingston, Canada

Rachel Webster
University of California (Berkeley), USA

Brian Schmidt
Queen’s University Kingston, Canada

Chris Wolf
Max-Planck-Institut für Astronomie, Heidelberg, Germany

Brian Schmidt
Radboud University Nijmegen, The Netherlands

Chris Wolf
University of Oxford, UK

Bonnie Zhang
Harvard-Smithsonian Center for Astrophysics, USA

Stuart Wyithe
Harvard-Smithsonian Center for Astrophysics, USA

Lister Staveley-Smith
University of Oxford, UK

Keck Telescope, Hawaii, USA
Large Synoptic Survey Telescope (LSST) Roadshow

The Large Synoptic Survey Telescope (LSST) is an 8.4-m optical and infrared telescope about to commence construction on Cerro Pachón, Chile. CAASTRO, in conjunction with AAO, ANU, Swinburne and ICRAR hosted an LSST roadshow in Sydney, Canberra, Melbourne and Perth during 27–31 October 2014. LSST offers many scientific opportunities and synergies for Australian astronomers. The aim of the roadshow was to initiate discussion about Australian participation in LSST. Our special guests for these events were Professor Steven Kahn (LSST Director) and Professor Željko Ivezić (LSST Project Scientist).

Each workshop featured LSST overviews from Professors Kahn and Ivezić, and contributed talks from Australian astronomers on proposed LSST science. There was strong and positive discussion about LSST and Australian participation at each location.

LSST as an all-southern-sky, imaging survey, is highly complementary to the Australian community’s interest in large-scale radio and spectroscopic surveys. At present Australia does not have access to contiguous digital optical imaging in the southern hemisphere (Sloan Digital Sky Survey, SDSS, only covers 2200 square degrees south of +10 deg declination). While SkyMapper improves this situation, in terms of the static sky, the main advantage of LSST over other large area surveys is in the expected average seeing of 0.7 arcsecond which allows better star-galaxy separation. Over the 10-year period 2022 to 2032, LSST will image 18,000 deg$^2$ of the sky in six bands, visiting every position about 800 times to reach a final co-added magnitude limit $r = 27.5$. LSST will be transformational for a wide range of topics in astronomy, including weak lensing, baryon acoustic oscillation studies, supernovae, near-Earth objects, stellar astronomy, galaxy evolution, Galactic structure and transients. LSST will also explore new frontiers in astronomy data management, producing 30 TB of data and approximately one million transient alerts per night.

ASKAP Commissioning & Early Science (ACES) Busy Weeks

Over the past year the ASKAP Commissioning and Early Science (ACES) Team has been holding regular busy weeks to combine in-house CSIRO expertise with University researchers from across Australia. Led by Dave McConnell, the team includes CAASTRO research fellows Emil Lenc, Attila Popping and Pietro Procopio, and affiliates James Allison, Keith Bannister and Martin Bell. The novel phased-array feed technology, already being used with the 6-antenna test array, enables astronomers to produce a single image that would normally take multiple observations with a traditional interferometer. These activities have produced impressive results, with fantastic images of the radio sky, containing thousands of distant active galaxies. Stay tuned in 2015 for a number of early science papers, including discoveries of jet-gas interactions in young radio galaxies (Allison et al., submitted to MNRAS), wide-field imaging and kinematics of HI gas in galaxy groups (Serra et al., in prep.), and monitoring of intermittent pulsars (Hobbs et al., in prep.).

MWA Workshop

The MWA expansion workshop was held at CAASTRO headquarters at the University of Sydney during 15–16 October. The purpose of the workshop was to share the MWA Director Steven Tingay’s vision for future phases of expansion for the MWA and for science teams to discuss new science programs that could be supported by an enhanced MWA.

The workshop was well attended with representatives from all the MWA key science programs and from CSIRO, CAASTRO and the MWA Board. The presentations covered a myriad of topics, from ambitious new science like detecting the cosmic web to practical issues of maintaining radio-quietness at the Murchison Radio-astronomy observatory.

The meeting concluded with MWA Staff Scientist Randall Wayth presenting a proposed timeline for concluding array configuration discussions and the Director’s plan for securing funding and expansion in 2015. The MWA is an active and productive telescope, and its future is exciting.

CoEPP/CAASTRO Joint Workshop

In February 2013, CAASTRO and the ARC Centre of Excellence of Particle Physics at the Terrascale (CoEPP) held their first joint Dark Universe meeting at The University of Melbourne. One of the outcomes of that meeting was a decision to pursue an Australian dark-matter direct detection experiment. Towards the end of 2013, the Northern Grampians Shire Council contacted CAASTRO’s Kate Mack, interested in her description of direct detection experiments overseas. This idea was progressed by CoEPP, and members of the Melbourne and Swinburne Physics groups began talks with the managers of the mine to discuss the possibility of using a portion of the mine as an underground physics lab.

The 2nd CAASTRO CoEPP joint workshop, which occurred at the Seppelts Winery in the rural Victorian town of Great Western over 28–30 September 2014, was an opportunity to build on those collaborations and to make concrete plans for an exciting new opportunity in dark-matter research. In addition to bringing together local and international experts on all aspects of dark-matter research, the workshop was also designed around introducing the scientific community to a proposal for the dark-matter detector in the Stawell gold mine.

Attendees at the workshop included members of a preliminary collaboration with scientists at the INFN in Italy, as well as the Science Attaché for the Italian Embassy. Discussions at the workshop touched upon the radiation and cosmic-ray-shielding conditions at the Stawell mine, both of which appear to be acceptable. CoEPP has already received encouragement from the local Stawell council, and several public meetings have shown a great deal of community support.
2014 Women in Astronomy Workshop

In 2014 CAASTRO supported the annual Astronomy Society of Australia Women in Astronomy workshop held in Canberra during 28–29 August 2014. Over the past three years the workshop has explored the important issues of unconscious biases and leadership development for women. The theme this year was “We are all made of stars: establishing equity and diversity within Australian Astronomy.”

Attendees at the Workshop included astronomers, scientists, engineers, technical and administrative staff, who examined what we as a profession can do to improve gender, racial and sex-based equity within our field.

Some high-profile speakers inspired, and encouraged change for the audience. Elizabeth Broderick, Australia’s Sex Discrimination Commissioner and a highlight speaker at the conference, presented the outcomes of the “male champions of change” initiative. Gender equity does not come about by women working alone. Male champions, in their positions of influence, are standing up alongside women to give voice to gender and equity issues.

The Hon Michaelia Cash MP, Minister Assisting the Prime Minister for Women, opened the conference and said “75% of astronomers are men, so 75% of the solutions on gender in your field need to be coming from men […] because women’s issues are men’s issues and in the end, they are just people issues.”

Dr Cordelia Fine, an academic psychologist and Associate Professor at the Melbourne Business School, University of Melbourne, introduced us to the term ‘neurosexism’. She explained how scientific studies on brain functionality have been used to reinforce gender stereotypes in ways that are often not scientifically justified.

Dr Megan Clark, Chief Executive of CSIRO, summarised the Workshop by saying that every leader needs to be responsible for ensuring diversity within their team and setting targets to achieve this.

ASA Early Career Researcher Mentoring Workshop 2014

CAASTRO also supported the Astronomical Society of Australia (ASA) second Early Career Researcher Mentoring Workshop in 2014. The workshop took place over 2–3 June at Cedar Creek Lodges on Tamborine Mountain in the Gold Coast hinterland close to Brisbane, QLD. The purpose of the workshop was to address topics related to career progression for the future leaders in our astronomy community. The workshop was aimed at postdocs, finishing PhD students, very junior faculty, and anyone beginning to establish themselves and looking for career guidance. The sessions included presentations and also discussions and other thought-provoking activities with participation and interaction.

Supernovae in the Local Universe Conference

CAASTRO’s “Supernovae in the Local Universe” was held during 10–15 August 2014 at Coffs Harbour in NSW and was the second in the annual series of CAASTRO conferences in wide-field astronomy. The meeting was successful attracting over 140 professional astronomers from 24 countries to Coffs Harbour to celebrate the life and death of an exploding star.

Exploding stars, supernovae, are not just a curiosity: they made all the gold, platinum, cobalt, nickel, and lead we have on Earth. With his colleagues, Brian Schmidt used exploding stars to measure the expansion of the universe, for which he was awarded the Nobel Prize in Physics in 2011.

The week-long conference particularly celebrated one star seen exploding in 1987 — 10,000 days ago. Called supernova 1987A, it was the brightest exploding star seen since telescopes were developed, and the one that most changed our understanding of what happens in these events.

SN 1987A was a supernova in the outskirts of the Tarantula Nebula in the Large Magellanic Cloud, a nearby dwarf galaxy. It occurred approximately 160,000 light-years from earth, close enough that it was visible to the naked eye in the southern hemisphere. It was the closest observed supernova since SN 1604, which occurred in the Milky Way itself.

The light from the new supernova reached earth on February 23, 1987. As it was the first supernova discovered in 1987, it was labelled ‘1987A’. It was the first opportunity for modern astronomers to see a supernova up close, and observations have provided much insight into core-collapse supernovae.
Participants included Kate Scholberg (neutrino hunter from Duke University, USA) and the renowned amateur supernova hunter, the Reverend Bob Evans. Dick McCray gave an excellent overview of the remnant around SN 1987A. The conference also marked the 65th birthday of supernova supremo Professor Robert (Bob) Kirshner of Harvard University.

Science highlights from the conference include the discovery that a very high fraction of massive stars have companions, as well as the very first detection by the Hubble Space Telescope of a star whose white dwarf companion exploded as a faint thermonuclear supernova. Scientists at the conference also presented an array of novel techniques for finding and studying supernovae, such as the Gaia and Kepler satellites, massive neutrino detectors, and new facilities hunting for elusive gravity waves.

SN 1987A itself was the focus of many science talks at the conference, with astronomers presenting observations spanning from ultra-high-energy gamma-rays and X-rays, through visible and infrared light, down to the lowest-energy radio wavelengths. After nearly thirty years, this unique event continues to inspire and inform astronomers about the fundamental nature of exploding stars.

This conference received a large amount of media interest, with two articles in the local newspaper Coffs Harbour Advocate, a segment on both the Prime and NBN TV News, and a number of foreign language SBS radio appearances from the conference’s invited speakers. It was a very successful week of science and networking.

Many of the projects discussed at the meeting, such as SAMI, some of the MWA projects, and the upgrade of MOST, were still being planned at the time of previous CAASTRO retreats, but are now beginning to produce results, to the clear satisfaction of both speakers and listeners.

Now former CAASTRO Director Bryan Gaensler was farewelled in style at the conference dinner, with Lister Staveley-Smith (UWA), Anne Green (Sydney), Steven Tingay (Curtin), Kate Gunn (Sydney) and new Director Elaine Sadler (Sydney) all praising his leadership.

The Annual Retreat ran very smoothly, thanks to the hard work of the CAASTRO A-team. Special thanks are due to Kylie Williams for planning and running many excellent CAASTRO events during 2014.
CAASTRO Voyages to the Red Centre

This year saw the start of our “Uluru Astronomer in Residence” program with industry partner, Voyages Indigenous Tourism Australia. This program saw fourteen CAASTRO members spend two weeks each at Uluru as the CAASTRO ‘Astronomer in Residence’. Under the leadership of Mike Dalley, Ayers Rock Resort Stars Department Manager, each of these astronomers spoke to the public on a daily basis in the town square about their research and CAASTRO, as well as doing some solar observing. In the evenings, the astronomers helped out with star tours and the renowned “Sounds of Silence” dinner. This has been a fantastic experience for both astronomers and the tourists alike and the program will expand in 2015. The astronomers’ adventures can be followed on the new @CAASTROUluru Twitter account. This year’s highlights included plenty of photography from Dr Sean Farrell and Dr Inoikis Konstantopoulos, Dr Richard Scalo’s visit to Yulara School, and the fantastic questions from all of the children.

Planetarium show

Our collaboration with Museum Victoria is progressing towards the production of the planetarium show “A new era of astronomy”, featuring key CAASTRO projects and telescope facilities. The show will introduce the public to the concept of all-sky astrophysics as the new and unique approach that will take astronomy into the next golden age. In 2014, the collaboration’s management team discussed and decided on a production script, based on which a few scenes were developed and are being reviewed by selected CAASTRO researchers who are experts on the particular topic in question. We are very excited about the previews and are looking forward to more sequences being produced and to live action filming at the two nominated telescopes sites, Siding Spring Observatory and the Murchison Radio-astronomy Observatory (MRO).

Telescopes in Schools

The University of Melbourne’s “Telescope in Schools” (TiS) program just completed its third year and now boasts 11 schools and well over 3000 students having looked through the telescopes. CAASTRO has continued our proud support of this program with regular visits from members to the schools. PhD students Jennifer Riding and Antonios Katsianis are regular attendees at Gisborne Secondary College and Northcote High School, respectively. The TiS program coordinator and temporary 2014 CAASTRO outreach officer, Jacinta den Besten, always attends the school observing sessions armed with CAASTRO rulers, balls and copies of the “CAASTRO Readers Digest”.

A Space Oddity

The team from Science Alert organized NASA Astronaut, Commander Chris Hadfield, to come out to Australia for National Science Week. Famous for his rendition of David Bowie’s “A Space Oddity” in zero-G while on the International Space Station, Commander Hadfield took to the stage in sell-out shows in Sydney and Canberra to talk about his experiences and sing a song. CAASTRO Affiliate Dr Katie Mack shared the stage with the famed astronaut for all three shows talking to audiences about dark matter. Chief Investigator Professor Brian Schmidt joined the tour for the Canberra leg, taking the Commander out to Mt Stromlo and participating in the show in the evening. CAASTRO was a proud sponsor of this overwhelmingly successful event, wrapping up a huge National Science Week for 2014.

Stars in the Yarra Ranges

Our continued support for the Mount Burnett Observatory in the Yarra Ranges, north-east of Melbourne, saw six members of CAASTRO present short talks on their research to over 400 members of the public over four nights during National Science Week. The members of the amateur astronomy group organised the week-long event at various venues throughout the Yarra Ranges including local schools and the Yarra Ranges Museum. Along with telescope observing activities and live feeds from extra-terrestrial telescopes, Dr Pietro Procopio, Mr Syed Uddin, Professor Chris Power, Professor Karl Glazebrook, Ms Emily Petroff and Dr Ewan Barl all gave very well received talks about current CAASTRO research. Each of the talks was recorded, and an overview of the week was created and can now be viewed on the CAASTRO YouTube channel. In addition to National Science Week, regular guest speakers from CAASTRO attended the Mount Burnett Observatory meetings, sharing their research and knowledge. Thanks are due to the organisation and enthusiasm of Dr James Murray, past Outreach Officer and new President, and his team at Mount Burnett as the partnership continues to flourish and CAASTRO’s outreach to a wider community grows.

Public Outreach

Our researchers continue to give public talks both throughout Australia and internationally discussing their research, astronomy in general, the future of science, and equality in astronomy. We are particularly pleased that both our senior and junior members actively engage in public outreach. Ten Perth-based members offered their expertise to the around 3,000 visitors of the CAASTRO booth at the 2014 Astrofest which featured a live watercolour of the radio frequencies as received by a single dipole antenna of the Murchison Widefield Array. CAASTRO Partner Investigator Professor Ray Norris, CSIRO, gave a lecture on “Indigenous Astronomy and Navigation”. Professor Tamara Davis spoke at TEDxNoosa and the BrisScience Event in Brisbane before heading over to Auckland, New Zealand, to share the stage with Professor Brian Schmidt to showcase “The Dark Side of Astronomy”. Naturally, Professor Schmidt’s schedule is difficult to sum up briefly but he also spoke at the Universities of Western Sydney and Tasmania, took part in video broadcast panel discussions at the ANU (“The Future of Education in an Online World”) and the National Library (“Seeing back to the Big Bang”), appeared at the Royal Society of Victoria fundraiser lunch, contributed to “Science at the Shine Dome”, spoke in Toronto, attended the Nobel Prize Awards, and was a key presenter at the inaugural SAGE (Science in Australia Gender Equity) workshop at the Australian Academy of Science.
Dr Katie Mack headed all over the world, both physically and virtually giving public talks both in person and through various podcasts, including one to India. She also explored the sounds of the Big Bang as a part of Melbourne Knowledge Week, “Pint in the Sky”, hosted by her and Dr Alan Duffy, also released new podcast episodes with many more to come in 2015. Dr Duffy was also busy with regular TV spots on ABC News commenting on the latest astronomy news, and he took part in the “Science of Dr Who” tour. In addition to Professor Bryan Gaensler continuing with his regular weekly Q&A session with Linda Mottram on 702 ABC Sydney, there were many other radio spots with participation by CAASTRO members.

School Engagement

In mid 2014, local coordination of our seminar program “CAASTRO in the Classroom (CiC)”, linking researchers from across Australia to schools in metropolitan and regional areas via video-conferencing technology, changed hands as we thanked Dr Janine Farnes and Dr Shane O’Sullivan for their efforts and welcomed the University of Sydney’s Dr Nicholas Scott and Dr Vanessa Moss into their new roles. The CiC program was re-launched in a modified structure in 2014 to align sessions more closely with the science curriculum. This led to a decrease in the total number but the dial-up rate of schools increased, and the program ran six CiC PLUS Curriculum Revision Lectures that were attended by almost 1,000 students. In addition, the CiC Virtual Classroom allowed us to record and store sessions such as the “Science of Dr Who” tour. The CiC PLUS format was extended to include one of our annual workshops, “Exploring the Universe”, CAASTRO former PhD student Kitty Le’s paper, illustrating how “Computers beat brainpower when it comes to counting stars”.

In addition to our “CAASTRO in the Classroom” program, we are very appreciative of our individual superstars who dedicate their time to talk to school students about their astronomy research and about careers in science. Two of these superstars to highlight in 2014 were University of Sydney PhD student Aina Musaeva who single-handedly organised a “Spaceday” at Hill End Public School in New South Wales. The event was joined by three more local schools, Hargraves, Wollar, and Glen Alice Public Schools, and reached around 60 students. In the evening, Hill End also hosted a community dinner for residents of the village with Aina leading the night sky viewing through telescopes. The partial solar eclipse in late April presented an opportunity that ICRAR-Curtin researchers Dr Kathryn Trott and Dr Randal Wraith used for outdoor astronomy outreach at Bannister Creek Primary School in Perth where visibility proved much more favorable than in the Australian Eastern states.

Providing a lasting “Astrophysicist’s Guide to Exploring the Universe”, CAASTRO former PhD student and new research staff member Dr Vanessa Moss featured in a video by the Government program “Bridges to Higher Education” that is available on YouTube. In addition to her virtual presence, she also visited Greystanes Public School and Catherine McAuley Catholic School in mid 2014. CAASTRO researchers Associate Professor Chris Power, Dr Nick Newton, and Mr Paul Scott-Taylor from ICRAR-UWA had the opportunity to show off their exciting galaxy simulations to students as part of an episode of Channel Ten’s children’s science show “Scope”. They explained what we can learn from these simulations and why we need supercomputers to run them.

CAASTRO Social Media

We continued communicating our science through the CAASTRO Twitter, Facebook and YouTube accounts, as well through news stories on our website. This communication strategy has proven a massive success with over 900 followers on Twitter, over 20,000 Facebook users who ‘like’ our page, and almost 100,000 video views of our YouTube channel. The latter was fed with the special “Pint in the Sky” recording from National Science Week 2013, starring Henry Reich (“Minute Physics”) and “Bad Astronomer” Phil Plait, generating over 10,000 views by themselves.

A new Video Press Release (VPR) was produced in April 2014, in conjunction with the publication of our ex-PhD student Kitty Le's paper, illustrating how “Computers beat brainpower when it comes to counting stars”.

Another CAASTRO press release, Dr Jean-Pierre Macquart’s and Professor Ue Li Peri’s “Galactic lens yields precision pulse measurements” was accompanied by a short animation of a spinning pulsar that attracted over 27,000 views. This overwhelming response highlighted the value of high-quality visualisations of CAASTRO research, to which end we are continuing to work with the talented team at Swinburne Astronomy Productions to add more such animations to our library. The CAASTRO website received over 68,000 views throughout the year, with just under a quarter coming from Australia and the rest internationally. The ‘News’ section, in particular, with its frequent influx of short research stories (on average, every fortnight) and press releases provides an attractive port of call for CAASTRO students and postdocs.

Professional Development

The annual training workshop for our students and staff ahead of the 2014 CAASTRO Annual Retreat was presented by Dr Phil Crosby from CSIRO in Perth on the topic “Launching big projects in astronomy”. Taking place at the University of Queensland in Brisbane on Tuesday 18 November, 30 Postdoctoral researchers and students learned about the challenges, risks, and rewards in project management. Having previously worked in Industry, Dr Crosby was selected to join the SKA Program Development Office in Manchester, UK, as Manager for Industry Participation Strategy. His expertise in seeing an astronomy project from conception via construction to completion made him a very engaging trainer to our members, who enjoyed the day. The participants self-assembled into workgroups to tackle questions and tasks and even came up with a project to create a ‘death star’.

Networking and career advice by CAASTRO Mentors

CAASTRO continues to ensure our students and early-career researchers gain transferable skills, and advance their careers. To this end, in 2014 we continued our mentoring program designed to provide support and guidance to our early-career members by experienced mentors. The nature, frequency, and intensity of the mentoring sessions and activities are up to each mentor-mentee pair, with 1:1 video conferencing equipment installed at all CAASTRO nodes assisting the program through virtual meetings. At every CAASTRO Annual Retreat, we schedule formal and informal time for our mentors and mentees to have face-to-face discussions. In 2014 we re-introduced speed mentoring at the Annual Retreat to increase the mentoring opportunities for those who chose to participate.

CAASTRO also continues to have a good relationship with the ARC Centre of Excellence for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), centred on monthly meetings between our respective Centre Directors and COOs and a corresponding continuous exchange of ideas and practices. In October 2014, CUDOS and CAASTRO held a joint careers workshop for researchers and students at the University of Sydney. This program was considered highly valuable by participants who heard presentations from industry partners as well as other scientists.
CAASTRO at the International Centre for Radio Astronomy Research (ICRAR)

Astronomy and astrophysics research in Western Australia is largely conducted at ICRAR, which is an equal joint venture between Curtin University and the University of Western Australia (UWA). ICRAR is a single organisation with two physical nodes, located near the main campus of each university. ICRAR has a unified business plan and conducts joint research programs, seminars and senior undergraduate astronomy programs. CAASTRO’s engagement with ICRAR is through the CAASTRO Chief Investigators at the individual universities, Steven Tingay and Lister Staveley-Smith, who are Curtin and UWA node leaders respectively, and who are both Directors at ICRAR.

CAASTRO postdocs and students are mixed in with other ICRAR research groups, as encouraged by the ARC. Perth-area meetings are organised on a frequent basis by Se-Heon Oh and Cathryn Trott and alternate between Curtin and UWA. ICRAR’s significant pre-existing involvement with radio astronomy projects has allowed CAASTRO to leverage greater science return from its investment and benefit from considerable in-kind support from ICRAR’s engineering, ICT and science staff.
The Curtin Institute of Radio Astronomy was home to fourteen CAASTRO members in 2014 who contributed to the Dynamic and Evolving Universe research themes, the CAASTRO Education and Outreach program, and to the administration of the Curtin node.

In the Dynamic Universe, the Curtin team continued the hunt for, and analysis of, ‘fast radio bursts’ (FRBs), using the Murchison Widefield Array (MWA). With their pooled expertise in pulsars, high-time-resolution, voltage capture and statistics, CAASTRO is well positioned to be a major player in this exciting research field. Dr Steven Tremblay implemented an end-to-end pipeline to take raw voltage data from the MWA on-site and process incoherent fast transient event detection. In 2014, tens of hours of data were processed and used to provide a quality check on the pipeline and to refine methods for event detection. The CAASTRO Annual Retreat in November 2014 marked the start of coordinated follow-up observations that now see the MWA in Western Australia, along with the Giant Metrewave Radio Telescope (GMRT) in India, the Very Large Array (VLA) in the United States, and the Molonglo Observatory Synthesis Telescope (MOST) on the east coast of Australia, shadow CSIRO’s Parkes radio telescope in the search for FRBs. Also in high-time-resolution science, CAASTRO PhD student Samuel Oosterloo’s Astroblooms arrived. Dr Ramesh Bhat, Dr Stephen Ord, Dr Steven Tremblay and Professor Steven Tingay, cross-matched data from the MWA and from Parkes to identify giant pulses from the Crab pulsar.

In the Evolving Universe, the BIGHORNS Epoch of Reionisation (EoR) Global Signal project, led by Dr Wiebke Ebeling, and his team, continued the discovery of a fast radio burst in real-time, which enabled multi-wavelength followups for the first time. In the year ahead, Bhat plans to focus on further advancing the scientific capabilities for the MWA, while actively pursuing science with multiple instruments including the MWA, GMRT and the Parkes telescope.

The Curtin node is the headquarters of the CAASTRO Education and Outreach team: the program leader is Professor Steven Tingay and the program coordinator, Dr Wiebke Ebeling. Activities include news stories, press releases, social media, school engagement, public-outreach activities and professional training opportunities for CAASTRO junior members. Having established Science Outreach as a novel research field at Curtin, Dr Ebeling and Professor Tingay also co-supervised a third-year project student who looked at different presentation formats of all-sky data sets in research and outreach. The previously developed MWA demonstration tool was a well-received addition to the CAASTRO stand at Perth Astrofest in March 2014, and at the inaugural astronomy weekend at Uulu for National Science Week in August 2014. A successful press release originating from Curtin was the CAASTRO collaboration between Partner Investigator Professor Ue-Li Pen at the University of Toronto and Dr Jean-Pierre Macquart at Curtin in May 2014. Other Education and Outreach activities were conceived at and coordinated from the Curtin node and delivered nationally.

CAASTRO Curtin MSc student Mehran Mozammamparast graduated in 2014, having developed an alternative radiometric receiver for the BIGHORNS set-up. Two summer students were further involved in the BIGHORNS project in 2014, and characterised a new front-end receiver for the set-up to improve the accuracy of the signal calibration process. This new system will soon be deployed at the MRO and will bring the BIGHORNS team closer to having a chance of discovering the EoR.

Data collected as part of the MWA EoR project (led by Dr Cathryn Trotti) were successfully run through the pipeline for estimating the EoR power spectrum CHIPS (Cosmological HI Power Spectrum). The outputs were consistent given the amount of data and instrumental effects. The team continued to develop a better understanding of the impact of foregrounds on EoR detection, developed techniques to treat foreground contaminants in the data, and compared different observational techniques for performing the EoR experiment. This research has resulted in several papers that contribute to the literature in this field.

Prof Steven Tingay
CAASTRO Chief Investigator, Node Leader, Education and Outreach
Themes: Dynamic, Evolving
Tingay’s CAASTRO involvement continues to span the administrative, as member of the CAASTRO Executive, and the scientific. Tingay’s interests in time-domain astronomy and instrumentation are reflected in his involvement with other CAASTRO staff in work to detect pulsars and fast radio bursts with the Murchison Widefield Array (MWA). Tingay’s involvement in Epoch of Reionisation research, both via global signal and power spectrum techniques, continues strongly within CAASTRO. As Director of the MWA, Tingay has played a high level role in delivering one of the key elements of Australia’s next-generation astronomy infrastructure, an element that forms a significant pillar of CAASTRO’s scientific success.

Dr Ramesh Bhat
CAASTRO Associate Investigator
Theme: Dynamic
Bhat’s research continues to focus on observational pulsar astronomy and the transient radio Universe. Highlights from 2014 include him pioneering the first pulsar science publication with the newly-developed high-time-resolution capability for the MWA, and his involvement in the discovery of a fast radio burst in real-time, which enabled multi-wavelength followups for the first time. In the year ahead, Bhat plans to focus on further advancing the scientific capabilities for the MWA, while actively pursuing science with multiple instruments including the MWA, GMRT and the Parkes telescope.

Dr Wiebke Ebeling
CAASTRO Education & Outreach Coordinator
Theme: Education & Outreach
Ebeling project manages all activities in the CAASTRO Education and Outreach program and liaises with program collaborators throughout Australia. In 2014, Ebeling continued to support Astrofest, “CAASTRO in the Classroom”, National Science Week, “Telescopes in Schools” and Mount Burnett Observatory and was responsible for the CAASTRO website, social media channels, press releases and “CAASTRO Reader’s Digest” booklets. New additions to Ebeling’s portfolio were the partnership with Voyages Indigenous Tourism Australia, the CAASTRO planetarium show by Museum Victoria, and the production of a research specific media library by Swinburne Astronomy Productions. Ebeling published in her previous research field (neuroscience) in early 2014 and supervised a Curtin University third year project student in the newly established research field Education and Outreach in the first half of 2014. Ebeling also represented CAASTRO in the “Education, Outreach and Careers” Working Group to advise the National Committee for Astronomy for the Decadal Plan for Australian Astronomy 2016-2025.
Mr Mehran Mossammaparast
CAASTRO Masters Student
Theme: Evolving
Mossammaparast carried out extensive receiver characterisation including RF characteristics and temperature variations in a controlled laboratory environment. The receiver that he built is now ready to be integrated and tested in the BIGHORNS system. Mossammaparast completed his thesis for his M.Phil. in 2014.

Mr Samuel Oronsaye
CAASTRO PhD Student
Theme: Dynamic
In 2014, Oronsaye focused on the analysis of the Crab giant pulses observed simultaneously with the MWA and the Parkes radio telescope. The result of the analysis has been published and he wrote a paper currently undergoing collaboration review, and to be published in 2015.

Dr Marcin Sokolowski
CAASTRO Postdoctoral Researcher
Theme: Evolving
In early 2014 Sokolowski worked on improvements in the BIGHORNS system stability and calibration. In April 2014, Sokolowski and Wayth deployed the mobile system at the Wondinong Station in Western Australia. The inland location was chosen in order to avoid radio-frequency interference (RFI) identified in the data previously collected at the Murchison Radio-astronomy Observatory (MRO). It was deployed at the MRO in October 2014 and has been collecting data since then. Thus, in the last part of the year Sokolowski was analysing the new data. Finally, in December he was also working together with his summer student Daniel Ung on characterisation and testing of the new front-end receiver which is planned to be deployed at the MRO in early 2015 in order to improve accuracy of the signal calibration.

Ms Kim Steele
CAASTRO Honours Student
Theme: Evolving
Steele was part of the ‘Student Army’ who helped constructing the 128-telescope Murchison Widefield Array (MWA) in Western Australia. Her Honours thesis “Measuring HI absorption in distant quasars with the Murchison Widefield Array” used MWA commissioning data to look for absorption in the radiative rate of the transition 1\textsuperscript{12}CO (1-0). The work confirmed previous results on this source and continued into 2014 with new data from the full MWA.

Dr Steven Tremblay
CAASTRO Postdoctoral Researcher
Theme: Dynamic
In 2014, Tremblay led the commissioning of the Voltage Capture System (VCS) on the MWA. This commissioning was completed and the system is now in general use by MWA observers. During this process, a number of his work involves searching for RRAIs and bursty pulsars with the MWA and uses the VCS to do so. Additionally, Tremblay worked on the BIGHORNS EOR Global Signal Experiment. This system was deployed this year at the Murchison Radio-astronomy Observatory and is now taking continuous sky data. Further work on calibration of the system is underway at Curtin University.

Dr Cathryn Trott
CAASTRO Affiliate
Theme: Dynamic, Evolving
Trott’s work in the Evolving Universe theme has focused on designing and implementing an Epoch of Reionisation (EoR) estimation algorithm, for application to data from the MWA. Trott is also leading efforts to understand the impact of foreground contamination on EoR estimation. Trott has derived a framework for understanding the noise properties of EoR datasets with low-frequency radio interferometers, contributing to the optimal design of EoR experiments. Trott continued her collaborative projects in 2014, which included a medical internship at Harvard to evaluate the utility of new medical imaging techniques for estimating the size and location of tumours. Trott also has an active collaboration with the Radiation Physics group at the University of Sydney. As part of the Dynamic Theme, Trott contributes across a range of projects predicting the detectability of Fast Radio Bursts detections with the MWA and SKA-Low, developing a framework for accurately interpreting the results of current surveys, and understanding the statistical properties of high time resolution data in order to detect signals more efficiently. Trott is also performing cross-theme work, exploring the impact of ionospheric and interplanetary-induced intensity variations on the detectability of the EoR.

Mrs Angela Dunleavy
Administrative Coordinator
Dunleavy is responsible for collating non-financial data for CAASTRO reports and provides administrative support to the CAASTRO team at Curtin and at CAASTRO Annual Retreats.

Ms Tina Sallis
Finance Manager
Sallis is responsible for financial support to the CAASTRO team members and Curtin and for reconciliation of financial data against the CAASTRO budget.

The UWA node of CAASTRO is situated at the International Centre for Radio Astronomy Research (ICRAR), a joint venture of Curtin and UWA. ICRAR has a vigorous research program involving continuum and HI surveys, optical surveys and cosmological and galaxy-formation simulations, which perfectly complements the research focus of CAASTRO researchers at UWA and other nodes.

Activities this year
CAASTRO research at UWA has ramped up this year with the appointment of two new CAASTRO researchers, Popping and Rhee. This now brings the number of CAASTRO postdoctoral research appointments at UWA to five. There was considerable research activity in 2014 in studying the kinematics of galaxies, both on a cosmological scale and a local scale through surveys such as 2MTF and SAMI, and through simulation and other observations.

CAASTRO researchers at UWA have contributed to CAASTRO’s Dynamic science theme as follows:

- Staveley-Smith, with Gaensler and PhD student Zanardo, led a paper with exciting new data from the Atacama Large Millimeter/sub-millimeter Array (ALMA) and the Australia Telescope Compact Array (ATCA), which detailed the relative contributions of dust and synchrotron emission in the remnant of the famous Supernova 1987, and examined a possible new contribution from a pulsar wind nebula.

- Trott is also performing cross-theme work, exploring the impact of ionospheric and interplanetary-induced intensity variations on the detectability of the EoR.

- Major contributions to the Evolving science theme have been:
  - Cui is currently finalising his research on the cosmic web.
  - As part of a joint program between the SAMI/GAMA/DINGO teams, Meyer, Obreschkow, Popping, Staveley-Smith and other CAASTRO members commenced a Jvla survey to carry out widefield HI observations in the G09 field. In January, they obtained ~60 pointings in this region, initially selecting fields to maximise the direct detection of SAMI sources. These observations will be used to carry out studies of angular momentum in galaxies, the impact of group environment on galaxy evolution, and HI stacking experiments at intermediate redshifts.
  - Meyer, Popping, and other members of the DINGO and WALLABY survey teams obtained three ASKAP-BETA observations of the southern GAMA G23 region, which will ultimately also be the target for the DINGO ultra deepmap project. This data will be used for HI stacking experiments in the nearby Universe, with a comparison of results to existing Parkes data.
  - Popping and Meyer started reducing new VLA data targeted at the GAMA fields to perform a stacking experiment and measure the cosmic gas evolution back to almost half the age of the Universe. The upgraded VLA allows measuring neutral hydrogen at redshifts that are currently unexplored.

- Popping contributed to the development of a new software package to perform automated source finding called SoFIA (Source Finding Application). This package is now publicly available and resulted in an acceptance for publication. The use of this software will be to perform source finding and parameterisation for the DINGO and WALLABY projects.

- Popping and Meyer have successfully tested and implemented CASA scripts to combine data and generate image cubes for the CHILES (Cosmos HI Large Extragalactic survey). CHILES is a large project on the VLA where a single pointing will be observed for 1000 hours. This ongoing project is the ultimate precursor for future HI surveys on ASKAP.

- Further development of the WALLABY 2D kinematics pipeline for resolved galaxies has occurred. Tests are being conducted on data from existing HI surveys in preparation for ASKAP.

- Investigation of central dark-matter distribution in nearby (< 11 Mpc) dwarf galaxies from high-resolution HI galaxy survey has concluded and a paper has been accepted for publication.

- Cosmological galaxy formation zoom simulations have been used to study Milky Way-mass galaxies in different environments.

- Important limits have been placed on the temperature of dark matter using galaxy-clustering measurements.

- Major contributions to the Dark science theme have been:
  - In a major milestone, Springob has led the publication of a cosmographic analysis using data from the 6dF Galaxy Survey. The paper was...
accompanied by the public release of the peculiar-velocity data.

- Additional papers co-authored with the 6dF Galaxy Survey team at other nodes include the Fundamental Plane data release paper (Campbell et al. 2014) and the first cosmology results paper (Johnson et al. 2014).

- Peculiar velocities have also been derived for the 2MASS Tully-Fisher Survey (2MTF). The first measurement of the bulk flow of the local Universe using 2MTF has been published by PhD student Hong. This is the most accurate current measurement and was the basis for his PhD thesis, which was successfully defended this year.

- A cosmographic of the 2MTF peculiar-velocity field is under way.

- Planning for the TAIPAN survey has commenced.

**Future goals**

Over the next year, researchers at CAASTRO’s UWA node aim to:

- complete the first analysis of Parkes HI intensity mapping experiment
- conclude analysis of HI spectral stacking studies in the COSMOS and VVDS fields
- lead an alternative cosmology simulation comparison project, collaborating with other groups, including the WiggleZ, TAO, SAMI and GAMA teams
- development of a physically-based model of the emission of radio continuum emission from AGN and star-forming galaxies
- contribute to ASKAP early science with stacking experiments
- analyse HI data from the JVLA in the GAMA regions to measure the cosmic gas density by using stacking techniques
- reduce and analyse HI data from the widefield JVLA program to study the angular momentum properties of SAMI galaxies, the impact of group environment on galaxy evolution, and to carry out further HI stacking experiments at intermediate redshifts
- complete the WALLABY 2D kinematics pipeline and publish a series of pipeline papers including the WALLABY velocity field extraction algorithm
- derive a (improved) rotation curve of the Large Magellanic Cloud (LMC) and mass model using the newly developed pipeline
- apply the pipeline to SAMI velocity fields and HI data from early ASKAP observations
- establish how satellite galaxy properties depend on the underlying dark-matter model and galaxy formation physics
- produce synthetic galaxy surveys in non-standard cosmological models of dark matter and dark energy
- complete the cosmographic analysis of 2MTF, and submit for publication
- continue analysis of 6dF Galaxy Survey peculiar velocities and bulk flow
- assist the TAIPAN collaboration to complete a survey strategy that accounts for the various scientific objectives
- contribute to the first data release of the Galactic and Extragalactic All-sky MWA survey (GLEAM)
- assemble the first samples of radio galaxies based on GLEAM.

**Professor Lister Staveley-Smith**

**CAASTRO Deputy Director**

**Themes: Dark and Evolving**

Staveley-Smith is Node Director and CAASTRO Deputy Director. He leads the 2MTF project under the Dark Theme and the Intensity Mapping and Wallaby/Dingo projects under the Evolving Theme. His main research contributions have been in the 2MTF project with the successful graduation of PhD student Hong Taoyong and the publication of the first tranche of papers, and the commencement of the Intensity Mapping project, jointly led with Stuart Wyithe at Melbourne. He has also contributed to the Radio Galaxy Environments project, by ensuring the continued success of the MWA GLEAM survey.

**Dr Jonghwan Rhee**

**CAASTRO Postdoctoral Researcher**

**Themes: Evolving**

Rhee joined CAASTRO at ICRAR/UWA in June 2014. He has worked on Hi gas evolution out to z~0.4 using 21-cm HI emission stacking technique. Now he is working on an HI intensity mapping experiment using the Parkes radio telescope to extend the research to higher redshift (z~0.9). A large amount of data has been secured and more observations will be carried out in 2015 for WiggleZ fields. Using the data, Rhee will work on a data-analysis pipeline including removal of radio-frequency interference and foreground contamination from the observed data.

**Dr Weiguang Cui**

**CAASTRO Affiliate**

**Themes: Evolving and Dark**

Cui works on the cosmic web, using the cosmic web identification codes DISPERSE and Vweb, focusing on predictions of cosmic-web properties from simulations and comparisons with observation results. Cui also works on modified gravity/dark-energy simulations. He has a modified Gadget code to undertake cosmological simulations, and is applying a new minimalistic modified gravity (gamma) model to the new updated Gadget-3 code. In collaboration, he runs cosmological simulations under modified gravity and alternative dark-energy models, and documents the changes in halo properties and merger histories. Cui also investigates the cosmic web in those models to examine any major differences with the standard ΩCDM model.

**Mr Steven Murray**

**CAASTRO PhD Student**

**Theme: Evolving and Dark**

Murray has continued his doctoral research developing statistical tests and innovative software frameworks for fundamental calculations with dark-matter halos, under the supervision of Chris Power at ICRAR UWA. These calculations make semi-empirical predictions for the spatial clustering of galaxies, and are able to connect this to the properties of dark matter. Using this framework, he is exploring means of testing the nature of the dark-matter particles using current and next-generation massive galaxy surveys, and his software has also been implemented as a web application, attracting the attention of researchers across the globe.

**Associate Professor Danail Obreschkow**

**CAASTRO Affiliate**

**Theme: Evolving and Dark**

Within the Evolving theme, Danail Obreschkow is leading theoretical and observational studies of angular momentum in galaxies. As part of these studies, he is leading the analysis of angular momentum in the spiral galaxies of SAMI. Within the Dark theme, Obreschkow is developing and applying statistical estimators for observational cosmology, e.g. the velocity function and the line-correlation function to distinguish between different dark-matter models. He also collaborates with Meyer in the WALLABY and DINGO projects and studies of the Tully-Fisher relation.

**Mr Scott Meyer**

**CAASTRO PhD Student**

**Theme: Evolving and Dark**

Meyer is investigating the Tully-Fisher relation using stacked Hi profiles with his supervisors (Martin) Meyer, Obreschkow and Staveley-Smith. His research uses the S-cubed simulations and HIPASS data.

**Ms Clare Peter**

**CAASTRO Administrator**

Peter provides administrative support at the UWA node. She looks after the UWA node financials and reports back to the CAASTRO Chief Operating Officer. She works alongside the ICRAR UWA administration team.

**Dr Paul Scott-Taylor**

**CAASTRO PhD Student**

**Theme: Evolving and Dark**

Scott-Taylor has been investigating the formation and evolution of galaxies using simulation models with supervisors Power and Obreschkow, and co-supervisors Staveley-Smith and Andrew Benson (Carnegie Observatories, Pasadena). This investigation has focused on the development of new semi-analytic models that will enhance Benson’s Galform software and other codes, including METAXES, used to create the TIAMAT database (University of Melbourne). Scott-Taylor is also developing new software to model the distribution of Hi gas in galaxies. Scott-Taylor intends to use the simulation data produced by the software to create mock galaxy catalogs and simulated skies. These products will be delivered using the latest 3D visualisation techniques.

**Dr Attila Popping**

**CAASTRO Postdoctoral Researcher**

**Themes: Evolving**

Popping joined CAASTRO at UWA in March 2014. He was already an active member of the DINGO and WALLABY surveys on ASKAP and will continue to contribute to these surveys. He is also a core member of CHILES (the Cosmic HI Large Extragalactic Survey), which is a very large project on the VLA. Popping is working on several experiments to do Hi stacking and one of the goals is to use stacking techniques to do early science with ASKAP. Popping is member of the ACES team (ASKAP Commissioning and Early Science).

**Dr Se-Heon Oh**

**CAASTRO Postdoctoral Researcher**

**Theme: Evolving**

Oh has continued his work on the development of the WALLABY kinematics pipeline, particularly the tilted-ring analysis of 2D velocity fields based on Bayesian MCMC. A standalone C program has been developed and intensively tested using both simulated synthetic HI data cubes and those of the observed galaxies from ATCA LVPIS and VLA THINGS nearby.
Hi galaxy surveys. Oh has been working on a series of paper drafts that describe the pipeline algorithm and discuss its performance, and he aims to publish them early this year. Recently (Jan 2015), a paper ("High-resolution mass models of dwarf galaxies from LITTLE THINGS"), Oh et al. 2015) addresses the "cusp/core" problem in ACCM simulations, which was accepted for publication in the Astronomical Journal.

**Professor Chris Power**
CAASTRO Associate Investigator

**Themes: Evolving**

Power’s CAASTRO related work focuses on providing theory and simulations support for the SAMI galaxy surveys, in collaboration with CAASTRO investigators Obruchev and Croom, and on galaxy-formation modeling for future cold-gas surveys, in collaboration with CAASTRO investigators at the University of Melbourne (Kim, Wyithe) and at overseas nodes Durham University. He continues to supervise CAASTRO PhD students Murray (on the nature of dark matter and limits from future galaxy surveys), Scott-Taylor (on synthetic surveys for ASKAP and the SKA), and CAASTRO affiliate Cui (on modeling structure formation in non-standard cosmologies).

**Dr Chris Springob**
CAASTRO Postdoctoral Researcher

**Theme: Dark**

Springob has derived the Malmquist bias corrections for the 2MASS Tully-Fisher Survey (2MTF) peculiar velocities, and collaborated with Tao Hong on the analysis of these peculiar velocities. He has also examined the cosmography of the 6dF Galaxy Survey peculiar velocity field, working on comparisons with predicted velocity field models, which will also be applied to 2MTF.

**Dr Anna Kapinska**
CAASTRO Postdoctoral Researcher

**Theme: Evolving**

Kapinska joined CAASTRO at UWA in August 2013. She joined the Galactic and Extragalactic (GEG) Surveys MWA team to execute and complete the continuum studies of the MWA All-Sky Survey (GLEAM). The first data release is planned for late 2015. Kapinska is also part of the Radio Galaxies, Clusters & Cosmic Web GEG Science Team, focusing predominantly on radio galaxies and large scale AGN feedback; she investigates these subjects with the use of radio data and semi-analytical models. Kapinska also continues work on the LOFAR Deep Sky Surveys, which she joined in 2012. In addition, Kapinska is a science team member of a citizen-science project Radio Galaxy Zoo, devised as a pilot study for classifying complex radio sources from the upcoming EMU (Evolutionary Map of the Universe) survey that will provide us with enormous amount of data. In 2014 Kapinska become Project Manager for the EMU survey, which is to be conducted with ASKAP.

**Associate Professor Martin Meyer**
CAASTRO Associate Investigator

**Themes: Evolving**

Martin Meyer’s leadership role in the DINGO survey has seen him contribute to projects to stack HI data at moderate redshifts with telescopes such as Parkes, the VLA, and ASKAP-BETA. Studies of the cosmic HI density and the global Tully-Fisher relation are underway with PhD students. Through CAASTRO, he is also leading VLA survey program to obtain HI data of SAMI galaxies for a detailed study of angular momentum and galaxy evolution.

**Dr Richard Newton**
CAASTRO Affiliate

**Theme: Evolving and Dark**

Newton spent one year at ICRAR and CAASTRO at UWA from the Jodrell Bank Centre for Astrophysics as a Jim Buckee Fellow between November 2013 and November 2014. He worked on developing software for generating the inputs to simulations of galaxies and for creating rendered images and movies. He was a core member of the ICRAR/UWA simulations team who created and presented the "Spinning the Cosmic Web in a Supercomputer" planetarium show at Scitech in October 2014.

**Mr Tao Hong**
CAASTRO PhD Student

**Theme: Dark**

Hong is enrolled at the National Astronomical Observatories, Chinese Academy of Sciences and spent 50% of his time in Australia working on the 2MASS Tully-Fisher project (2MTF) as a CAASTRO student. He works with Springob and Staveley-Smith and has recently led a paper describing the first bulk flow measurements from 2MTF. Hong successfully defended his PhD thesis in 2014 and now holds a staff position at NAOC.

**Dr Dan Taranu**
CAASTRO Postdoctoral Researcher

**Theme: Evolving**

Taranu joined CAASTRO in late 2014 and his research areas are simulations of galaxy formation and evolution; synthetic observations of simulated galaxies; and modelling of spiral galaxies for the SAMI survey.

The CAASTRO Sydney node is located within the Sydney Institute for Astronomy (SIfA), which is part of the School of Physics within The University of Sydney. SIfA is one of Australia’s largest research groups in astronomy and astrophysics, and carries out observational and theoretical research as well as developing novel astronomical techniques and instrumentation. SIfA’s long-standing involvement in instrumentation and large-area astronomical surveys underpins many of the research activities at CAASTRO’s Sydney node.

With the change in CAASTRO Directorship in September 2014, Elaine Sadler also took over from Bryan Gaensler as the Sydney node leader. In 2014 there were 31 CAASTRO team members at the Sydney node, including 10 students. The main research activities at the Sydney node fall within the Evolving and Dark themes.

In the Evolving Universe theme, our major activities for 2014 (and the researchers involved in them) included:

- **The SAMI Galaxy survey**, an ambitious new study of the internal structure and kinematics of stars and gas within galaxies that uses a novel ‘hexabundle’ multi-object integral-field spectrograph jointly developed by Sydney and AAD (Allan, Blind-Havetlorn, Bloom, Bryant, Croom, Fogarty, McElroy, Richards, Sadler, Schaefer, Scotti).
- Studies of the redshifted 21-cm absorption line of neutral hydrogen as a probe of the cold gas content of galaxies in the distant Universe, as part of the ASKAP FLASH survey (Allison, Curran, Gloawacki, Moss, Reeves, Sadler).
- Calibration and analysis of low-frequency radio data from the Murchison Widefield Array (MWA), with a particular focus on polarisation measurements and characterisation of the foreground source populations relevant to studies of the Epoch of Reionisation (Calihammer, Gasnner, Lenc).

In the Dynamic Universe theme, our main activities were:

- Continuing development of the data pipeline and analysis tools for two ambitious new radio transient surveys, MWA transients and ASKAP VAST, including a particular focus on (i) understanding and calibrating ionospheric effects in MWA data and (ii) analyzing large archival radio, optical and X-ray data sets to identify new and rare classes of transient sources (Burlon, Gaensler, Loi, Musaeva, Murphy).
- Upgrading the Molonglo radio telescope to a system with increased bandwidth and a new digital correlator, in collaboration with CAASTRO CI Matthew Bailes and colleagues at Swinburne. The huge collecting area and wide field of view of the Molonglo telescope will make this a powerful new facility for pulsar timing and identifying ‘fast radio bursts’ (Campbell-Wilson, Greenh.

Our visitors this year included Prof Roger Davies (Oxford), Dr Stephen Fine (University of Western Cape), Prof Martha Haynes (Cornell University), Prof Garth Illingworth (UC Santa Cruz), Prof Tom Landecker (University of Calgary), Dr Tom Mauch (SKA Africa) and Dr Kevin Schawinski (ETH Zurich), as well as the many researchers from other CAASTRO nodes who visited us for ‘busy weeks’ and workshops over the course of the year. In October 2014, we hosted a well-attended workshop on ‘Extended Capabilities for the Murchison Widefield Array (MWA)’. Our research highlights for 2014 are wide-ranging, and reflect the fact that two major new facilities with which we have been closely involved, MWA and SAMI, moved into full operational mode this year, while early results are also emerging from the commissioning phase of ASKAP. As a result, we are now starting to see exciting scientific returns from the effort put into survey design, data pipeline work and analysis tools over the past three years.

2014 saw the first public release of data from the SAMI galaxy survey, with a paper presenting fully-calibrated data cubes for a representative selection of 107 galaxies drawn from the GAMA regions, along with information about these galaxies from the GAMA catalogues. CAASTRO students Sam Richards and Adam Schaefer discovered a luminous star-forming complex in the outskirts of a dwarf galaxy observed by SAMI. This unresolved region contributes over 70% of the total star formation rate in its parent galaxy, and could easily have been missed in a conventional single-fibre spectroscopic survey.

This year also saw the first detection of neutral hydrogen in a distant galaxy with ASKAP. CAASTRO Affiliate James Allison and colleagues used commissioning data from the six-antenna test array to observe a set of bright, compact radio sources, and discovered a previously unknown HI absorption line at z = 0.44 towards a radio galaxy of unknown redshift. Optical spectroscopic observations (using Gemini South)
confirmed that the absorbing gas is located within the host galaxy of the radio source, and this represents an important milestone for Hi studies with ASKAP.

CAASTRO Honours student Cleo Loi discovered a series of spectacular wave-like structures in the ionosphere by analysing time-series data from the Murchison Widefield Array. Cleo’s work was initially motivated by a desire to understand the effect of variations in the electron density of the ionosphere on the measured positions and flux densities of distant radio sources, but she discovered that the wide-field nature and excellent snapshot capabilities of the MWA also make it a powerful instrument for ionospheric science which can probe the ionosphere on regional (1-100 km) scales. Cleo’s work represents the first time a radio telescope has been used to probe the ionosphere with such high spatio-temporal resolution over such a wide field of view.

One of our main education and outreach activities continues to be the “CAASTRO in the Classroom” (CiC) program, which uses our video-conferencing system to stream talks and discussion sessions with CAASTRO astronomers to high schools across New South Wales. Several Sydney node researchers and students also travelled to Uluru to take part in CAASTRO’s new ‘Astronomer in Residence’ program at the Voyages resort.

The University of Sydney hosts CAASTRO’s main administrative office, which in 2014 consisted of Kate Gunn (Chief Operating Officer), Debra Gooley (finance), Michelle Sullivan (executive support), Kylie Williams (events and communications) and Helen Sim (media and Annual Report). This team oversees a transparent reporting system across the Centre, handles all our financial obligations and transactions, organises our scientific workshops, manages the CAASTRO Mentoring Program and prepares the regular CAASTRO newsletter. A notable extra activity this year was the organisation and administrative support of the ARC Mid-Term Review of CAASTRO in November. A great deal of work went into making sure we were as well- prepared as possible, and it was gratifying to see things run so smoothly on the review day.

Professor Elaine Sadler

CAASTRO Director (from 15 Sep 2014)

Theme: Evolving

In 2014 Sadler has been working with Allison, Moss, Curran, Reeves and Glowacki on the identification and study of redshifted 21-cm HI absorption in galaxies out to redshift z = 1, using new tools and techniques developed for the forthcoming ASKAP FLASH survey. A particular highlight was the detection of HI absorption lines in early commissioning data from ASKAP, including the discovery of associated HI absorption in the radio galaxy PKS 1740-517. In 2015 they will continue a program of spectral-line observations as ASKAP moves into its Early Science phase.

Professor Bryan Gaensler

CAASTRO Chief Investigator

(Director until 15 September 2014)

Themes: Evolving and Dynamic

Gaensler leads the radio-galaxy environments project within CAASTRO’s Evolving Theme. In 2014, he worked on catalogues of broadband polarisation of active galaxies, which probe the ionised material in which these sources are embedded. He also began a new joint Evolving/Dynamic project on hydrodynamic cosmological simulations of fast radio bursts, which he used to constrain the spatial distribution and energetics of these events. In 2015, he plans to investigate in detail the polarised emission from individual galaxies within the broadband catalogues his team has derived, and to obtain early science polarisation data on radio galaxies from ASKAP and the MWA.

Associate Professor Scott Croom

CAASTRO Chief Investigator

Theme: Evolving

Croom is leading the SAMI Galaxy Survey within the CAASTRO Evolving Theme. This is a project to observe thousands of galaxies using spatially resolved spectroscopy with the Sydney-AAO Multi-object Integral Field Spectrograph (SAMI) on the Anglo-Australian Telescope. In 2014 the SAMI Galaxy Survey was in full swing, with over 1000 galaxies observed to date. Exciting new results published included the discovery of dwarf galaxies with extreme star-forming regions, the characterisation of gas outflows in galaxies and the demonstration of a new universal dynamical scaling relationship between galaxy mass and the internal motions of gas and stars. In mid 2014 the team also produced the SAMI Early Data Release of over 100 galaxies for astronomers around the world to use. In 2015 there is much science to look forward to, including investigations into the role of environment in determining star formation and dynamics in galaxies, tests of the role of super-massive black holes in preventing star formation, examining the distribution of young and old stars in galaxies, and much more.

Dr Tara Murphy

CAASTRO Chief Investigator

Theme: Dynamic

Murphy’s focus is on radio observations of transient and variable sources such as supernovae and gamma-ray bursts. In addition, she works on developing intelligent algorithms for detecting transient events in the large volumes of data that will be produced by next-generation radio telescopes. In 2014, Murphy used new low-frequency data from the MWA to investigate ultracool dwarf stars and exoplanets, as well as conducting a blind survey for radio transients.

Dr James Allen

CAASTRO Affiliate

Theme: Evolving

Allen has led development of the data-reduction pipeline for the SAMI Galaxy Survey, culminating in the Early Data Release of a subset of the survey galaxies. This data is now public, allowing researchers across the world to make use of the SAMI Galaxy Survey data. Allen has also been investigating the relationship between active galactic nuclei and their host galaxies, focusing on a small number of galaxies with unusual kinematic properties.

Dr James Allison

CAASTRO Affiliate

Theme: Evolving

Allison is a member of the ASKAP FLASH survey, which will probe the distribution and evolution of atomic hydrogen (HI) to high redshifts. His current research focuses on using HI absorption lines to study the role of neutral gas in fuelling active galactic nuclei and the subsequent feedback on the host galaxy. In 2014 he found a new HI absorption system in the young radio galaxy PKS 1740-517; the first discovery using the ASKAP six-antenna BETA prototype. In 2015 Allison will continue to make new discoveries with BETA and towards the end of the year he will help the FLASH team carry out an early science survey with ASKAP-12.

Dr Martin Bell

CAASTRO Postdoctoral Researcher

Theme: Dynamic

Bell is principle investigator of the Murchison Widefield Array Transients Survey (MWATS), which aims to survey almost the entire southern hemisphere multiple times at low frequencies, on timescales of one month. The aim of the project is to search for dynamic and explosive objects in the Universe. Bell is also a member of the Australian Square Kilometre Array Pathfinder (ASKAP) commissioning team. In the 2015 the team will prepare the instrument for early science later in the year.

Dr Julia Bryant

CAASTRO Postdoctoral Researcher

Theme: Evolving

Bryant is deeply involved in the SAMI instrument and the SAMI Galaxy Survey. In 2014 she chaired the SAMI Target Selection Working Group, and selects the galaxies to be observed in the SAMI Galaxy Survey, ...
as well as developing and maintaining the SAMI instrument.

She continues to use the SAMI data to investigate
whether gas gets into galaxies from internal or external
processes, by looking at the resolved dynamics of both
the gas and the stars in galaxies and the impact of
the environments surrounding the galaxies. Working
with Leslie and Sadler, she has on-going research into
the radio properties of the SAMI galaxies, and she
supervises PhD student Richards, who is researching
aperture effects within the SAMI data.

In 2015 Bryant will not only continue her SAMI science but will also be Project Scientist for a future large
integral-field instrument called HECTOR.

Dr Davide Burlon
CAASTRO Affiliate
Theme: Dynamic

Burlon is an expert on high-energy emission from black
holes. His main focus in the past year has been to pave
the way to the SKA in the theme of stellar explosions
known as gamma-ray bursts. He is advising the
Transients working group of the SKA.

Mr Duncan Campbell-Wilson
CAASTRO Affiliate
Theme: Dynamic

In the past year Campbell-Wilson’s work has consisted of
successfully developing a new radio receiver based
on integrated radio receivers, field-programmable
gate arrays and fibre optics. A number of subtle
difficulties in operating digital technologies adjacent
to very sensitive astronomical receiving equipment
were identified. Solutions have been identified and
tested. Implementing the engineering solutions is in
progress. A highlight this year was the successful
return of the telescope imaging capabilities using the
new receivers. Since this success, system development
and receiver fine-tuning has taken most of Campbell-
Wilson’s time. A number of critical systems within the
telescope infrastructure are being redeveloped with
newer technology. Testing of RF losses in materials
and the testing of a well matched wideband antenna
was successfully conducted at DRAO in Canada. The
CHIME team have further developed the antenna for
radio-astronomical applications.

Dr Steve Curran
CAASTRO Postdoctoral Researcher
Theme: Evolving
Curran is preparing for the First Large Absorption
Survey in HI, to be undertaken with the Australian
SKA Pathfinder, in the search for the cool, star-forming
material in the early Universe. In 2012, in conjunction
with Matt Whiting at CASS, he found that placing a
powerful quasar in a galaxy of gas will ionise all of the
neutral hydrogen (HI). Now, with James Allison
and their CAASTRO student, Marcin Glowacki, they
have expanded this to state-of-the-art optical data,
with preliminary results indicating that singly ionised
magnesium (MgII), which has a similar ionisation
potential to HI, is also absent in the host galaxies of
powerful quasars. The previous HI 21-cm observations,
which first alerted us to this effect, cannot rule out
that the gas is simply heated to beyond the detection
threshold of current radio telescopes. The fact that HI
and MgII exhibit a similar UV luminosity above which
neither is detected, supports the theoretical model that
ALL of the gas is indeed ionised. This has profound
implications for quasar-mode feedback in these
galaxies, through the suppression of star formation by
the active nucleus, and means that there may exist a
population of very distant gas-rich galaxies hidden from
optical surveys.

Dr Jamie Farnes
CAASTRO Affiliate
Theme: Evolving

Since joining CAASTRO in 2012, Farnes has been
organising the ‘CAASTRO in the Classroom’ programme
together with Shane O’Sullivan, and has very recently
handed over to new organisers. He’s very excited to
see how CAASTRO in the Classroom develops in the
future, and is looking forward to now focusing on
CAASTRO science in 2015.

Dr Sean Farrell
CAASTRO Affiliate
Theme: Dynamic

Farrell’s specialisation is X-ray astronomy, focusing
on the study of accreting compact objects (i.e. black
holes, neutron stars and white dwarfs). His research
in particular has targeted intermediate-mass black
holes and the role they played in the formation and
evolution of galaxies. As a CAASTRO Affiliate, in
2014 he applied machine-learning techniques to
automatic classify X-ray sources in the Third XMM-
Newton Serendipitous Source Catalogue (3XMM). He
also provided support through his expertise in X-ray
astronomy to various CAASTRO activities. In October
2014 Farrell left astronomy.

Dr Ilana Feain
CAASTRO Affiliate

Feain leads the development of a novel and cost-
effective radiotherapy machine designed to level the
playing field in global accessibility to equitable cancer
treatment. Feain obtained her PhD in Astrophysics
from the University of Sydney in 2006, and became
a research astronomer and project scientist on the
Australian Square Kilometre Array Pathfinder (ASKAP)
at CSIRO Astronomy and Space Science. This led to
Feain developing a cross-disciplinary research program
to enable ASKAP’s novel receiver technology to be used
beyond astronomy, including in health and defence. She
then made a major career change in 2014, when she
moved into medical physics, working in the Radiation
Physics Laboratory at the School of Medicine of the
University of Sydney.

Dr Lisa Fogarty
CAASTRO Postdoctoral Researcher
Theme: Evolving

Fogarty works on the SAMI Galaxy Survey – a
project to observe 3000 galaxies with integral field
spectroscopy (IFS). In 2014 Fogarty published the first
paper on the SAMI Pilot Survey, an investigation of the
angular momentum of early-type galaxies in clusters.
In 2015 Fogarty will extend this work, using the
main SAMI Galaxy Survey observations to investigate
the properties of galaxies in groups, to infer their
evolutionary history.

Professor Anne Green
CAASTRO Affiliate
Themes: Dynamic, Evolving

Green leads the upgrade to the capabilities of the
Molonglo telescope in collaboration with the Swinburne
Node. In 2014 the new system achieved ‘first light’
imaging and detected several pulsars. In 2015, Green
plans to focus on searches for transient sources at
cosmological distances and deep imaging of radio relics
and halos around massive galaxy clusters.

Dr Emil Lenc
CAASTRO Postdoctoral Researcher
Theme: Evolving

In 2014 Lenc primarily continued work to survey
polarised point-sources and diffuse polarisation as
part of the GLEAM/EoR projects within the MWA
collaboration and investigated the effect of the
ionosphere on polarisation at MWA wavelengths. He
also commenced work half-time as a commissioning
scientist for the Boolardy Engineering Test Array (BETA)
as part of a secondment to CSIRO. In 2015 he plans
to continue work on polarisation within the GLEAM
and EoR projects and to search for evidence of the
synchrotron cosmic web in diffuse emission mapped
with the MWA.

Dr Vanessa Moss
CAASTRO Postdoctoral Researcher
Theme: Evolving

Moss joined the First Large Absorption Survey in HI
(FLASH) team in mid-2014 and is working on science
preparations for this survey, which will be made using
the Australian SKA Pathfinder, as well as studies
carried out with its precursor, the Boolardy Engineering
Test Array. Her focus is on the galactic ecosystems
of both intervening and associated absorbing systems,
with an emphasis on their multi-wavelength footprints
determined from large-scale datasets.
Mr Joseph Callingham  
CAASTRO PhD Student  
Theme: Evolving  

Callingham has been working on spectral modelling of young radio galaxies using data from the MWA and ATCA. He has also been empirically modelling the primary beam of the MWA and constraining the low-radio-frequency flux scale for the southern hemisphere.

Mr Marcin Glowacki  
CAASTRO PhD Student  
Theme: Evolving  

Glowacki has joined the FLASH (First Large Absorption Survey in HI) team working with ASKAP in its Beta commissioning stage. The aim of FLASH is to search for cool, star-forming material in the early Universe through HI 21-cm absorption, and through this learn more about galaxy evolution across epochs. In 2014 Glowacki created a publicly accessible website to aid in target selection, and used this to compile a target list of bright, red quasars that was searched against for HI 21-cm absorption with ASKAP. Glowacki also assisted in observing nearby compact sources with the Australia Telescope Compact Array (ATCA), and subsequent data reduction and analysis.

Ms Cleo Loi  
CAASTRO Honours Student  
Theme: Dynamical  

Loi has been working with MWA data, looking for radio emission from low-mass stars and also characterising the ionosphere over the MWA. She completed an Honours project in 2014 supervised by Tara Murphy, with the aim of performing a climatological study of the ionosphere using existing data from MWA transient surveys. Loi is working to establish the MWA as a quantitative tool for geospace physics, its high sensitivity and wide-field nature allowing it to image the ionosphere in a novel and detailed way.

Ms Rebecca McElroy  
CAASTRO PhD student  
Theme: Evolving  

McElroy works on integral-field spectroscopy of active galaxies and is also a member of the SAMI Galaxy Survey. In 2014 she presented her first talk at an international conference and published her first paper on AGN feedback. In 2015 McElroy will be helping with SAMI observations, and working to combine her AGN dataset and the SAMI sample in a new comparison paper.

Ms Aina Musaeva  
CAASTRO PhD student  
Theme: Evolving  

In 2014 Musaeva submitted several X-ray and radio proposals for the previously identified most promising intermediate-mass black hole (IMBH) candidates, with some of them granted observing time in 2015. She presented the results of her research at an international workshop in Leiden, Netherlands, with her poster awarded the best poster of the workshop. At the end of 2014 Musaeva had a paper accepted (by Monthly Notices of the Royal Astronomical Society) on testing the hypothesis that the strongest candidate IMBH (MLX-1 in ESO 243-49) is the nucleus of a stripped dwarf galaxy.

Ms Sarah Reeves  
CAASTRO PhD Student  
Theme: Evolving  

Reeves is working on HI emission- and absorption-line studies of galaxies, as part of preparation for the ASKAP-FLASH survey. In 2014 she completed a study of HI emission and absorption in a sample of nearby galaxies with the ATCA, as well as working on a new HI absorption stacking project. Reeves’ focus in 2015 will be on finishing her PhD thesis, which she plans to submit in early 2015.

Mr Samuel Richards  
CAASTRO PhD Student  
Theme: Evolving  

In 2014, Richards presented the result of an isolated dwarf galaxy with an intense HII region on its outskirts (the “LMC’s lonely twin”), identified from the data of the SAMI Galaxy Survey. This dwarf galaxy, and ones similar to it, help in the evolutionary understanding of ‘clump-cluster’ systems at higher redshift (z ~1). Richards also used the resulting data from SAMI to test single-fibre aperture corrections that are used routinely in large surveys such as GAMA and SDSS. Identifying any systematic errors in these corrections is of great importance to studies of galaxy evolution in the local Universe.

Mr Adam Schaefer  
CAASTRO PhD Student  
Theme: Evolving  

Schaefer is a postgraduate student working on the theme of the Evolving Universe who joined CAASTRO in mid 2013. Using data from the SAMI Galaxy Survey Schaefer used spatially resolved spectroscopy to study the environmental dependencies of the star formation profiles within galaxies.

Ms Kate Gunn  
Chief Operating Officer  

A start-up specialist with a wealth of business and University experience, Gunn has been well placed to establish the necessary foundations for CAASTRO to grow and achieve its goals. She has 25 years of management experience, and has a background in the commercialisation of University intellectual property.

Ms Debra Gooley  
CAASTRO Finance Officer  

Gooley is responsible for the co-ordination and management of ARC Centre of Excellence KPI and financial reporting and other associated reports for CAASTRO, to support the achievement of the Centre’s goals and objectives.

Ms Michelle Sullivan  
CAASTRO Executive Assistant  

Sullivan provides executive assistance to the CAASTRO Director and other CAASTRO staff, including assisting the CEO and Events and Communications Officer with their duties.

Ms Kylie Williams  
CAASTRO Events and Communications Officer  

Williams coordinates the regular CAASTRO newsletter and organises various events hosted by CAASTRO around Australia.

Ms Helen Sim  
Public Relations Officer  

Sim has extensive experience in writing and performing public relations for scientists, and is skilled in translating complex information into language for non-technical audiences.
We developed a semi-analytic method for assessing the impact of the large-scale IGM temperature fluctuations expected following He II reionisation on three-dimensional clustering measurements of the Ly-alpha forest. Our methodology builds upon the existing large volume, mock Ly-alpha forest survey simulations presented by Greig et al. by including a prescription for a spatially inhomogeneous ionising background, temperature fluctuations induced by patchy He II photoheating and the clustering of quasars. This approach enabled us to achieve a dynamic range within our semi-analytic model substantially larger than currently feasible with computationally expensive, fully numerical simulations. We use these simulations to show that large-scale temperature fluctuations introduce a scale-dependent increase in the spherically averaged 3D Ly-alpha forest power spectrum of up to 20–30 per cent at wavenumbers k ~ 0.02 Mpc⁻¹. We show that although these large-scale thermal fluctuations will not substantially impact upon the recovery of the baryon acoustic oscillation scale from existing and forthcoming dark-energy spectroscopic surveys, any complete forward modelling of the broad band term in the Ly-alpha correlation function will nonetheless require their inclusion. (Greig, Bolton, Wyithe)

In 2014 we used high-resolution simulations of cosmological variants for our model galaxy formation at high redshift, with the goal of studying the photon budget for reionisation. We demonstrated that galaxy formation models include a strong, thermally coupled supernovae scheme reproduce current observations of star-formation rates and specific star-formation rates, both during and after the reionisation era. These models produce enough UV photons to sustain reionisation at z > 8 (z ≤ 6) through a significant population of faint, unidentified galaxies for an assumed escape fraction of 20 per cent (5 per cent). This predicted population is consistent with extrapolation of the faint end of observed UV luminosity functions. We find that heating from a global UV/X-ray background after reionisation causes a dip in the total global star-formation rate density in galaxies below the current observational threshold. (Duffy, Wyithe)

Estimating the intergalactic medium ionisation level of a region needs proper treatment of the reionisation process for a large representative volume of the Universe. The clumping factor, a parameter which accounts for the effect of recombinations in unresolved, small-scale structures, aids in achieving the required accuracy for the reionisation history even in simulations with low spatial resolution. In 2014, we made the first study of the redshift evolution of clumping factors of different ionised species of H and He. We investigated the dependence of the value and redshift evolution of clumping factors on their definition, the ionisation level of the gas, the grid resolution, box size and mean dimensionless density of the simulations. (Jeeon-Daniel)

The rapid decline in the number of strong Ly-alpha emitting galaxies observed at z > 6 provides evidence for neutral hydrogen in the intergalactic medium, but is difficult to explain with plausible models for reionisation. In 2014 we demonstrated that the observed reduction in Ly-alpha flux from galaxies at z > 6 can be explained by evolution in the escape fraction of ionising photons. Specifically we found that the median observed drop in the fraction of galaxies showing strong Ly-alpha emission, as well as the observed evolution of the Ly-alpha luminosity function, both follow from a small increase. More generally, our analysis also showed that the drop in the Ly-alpha flux is quantitatively consistent with the observed evolution in the Ly-alpha luminosity functions of Ly-alpha emitters. (Wyithe)

Dark matter self-annihilation holds promise as one of the most compelling ways of explaining the identification of the particle responsible for the Universe’s missing mass. In 2014 we examined the evolution of the dark-matter annihilation power produced by smooth and collapsed structures over cosmic time, taking into account uncertainties in the structure of dark-matter haloes. As astronomers search for observational signatures of annihilation, an understanding of this time evolution will help to provide a better proxy of stellar masses and are more complete at the high-mass end of the distribution. Our simulations predict a population of faint galaxies not seen by current observations. (Katsianis, Tesiari, Wyithe)

The correlation between 21-cm fluctuations and galaxies is sensitive to the astrophysical properties of the galaxies that drove reionisation. Thus, detailed measurements of the cross-power spectrum and its evolution could provide a powerful measurement of both the properties of early galaxies and the process of reionisation. In 2014 we studied the evolution of the cross-power spectrum between 21-cm emission and galaxies using a model which combines the hierarchical galaxy formation model GAlFORM implemented within the Millennium-II dark-matter simulation, with a semi-numerical scheme to describe the resulting ionisation structure. We found that inclusion of different feedback processes changes the cross-power spectrum shape and amplitude. In particular,
the feature in the cross-power spectrum corresponding to the size of ionised regions is significantly affected by supernovae feedback. We predicted observational uncertainties of the cross-correlation coefficient based on speciﬁcations of the Murchison Wideﬁeld Array (MWA) combined with galaxy surveys of varying area and depth. We found that the cross-power spectrum could be detected over several square degrees of galaxy survey with galaxy redshift errors \( \sigma_z \lesssim 0.1 \) (Kim, Wyithe) During 2014 we have used the MWA to undertake over 1000 hours of observations targeted at the key Epoch of Reionization (EoR) fields. Working with the EoR collaboration, we have developed systems to ensure that this data is archived at the Pawsey Centre in WA with appropriate quality-control ﬂags. We estimate that by the end of 2015 we will have obtained a sufﬁciently sensitive dataset to enable foreground removal and cosmic bias in each of our chosen ﬁelds. This experiment is designed to allow detection of the theoretically predicted HI signal of the EoR. (Webster, and the EoR collaboration; this includes Pindor, Procopio, McKinley, Line, Riding at Melbourne; Trot; Wayth, Tingay at Curtin; Ofﬁnga and Briggs at ANU; Lenc and Gaensler at Sydney; and Mitchell at CSIRO)

The ﬁrst analysis of the MWA data uses a novel approach to compare the output of four different and independent methods developed by the Australian and US EoR collaboration. The same three-hour dataset is analysed by each pipeline, allowing a direct comparison of the outputs. The ﬁnal output of each of these pipelines is compared using the two-dimensional power spectrum. This has allowed the EoR collaboration to understand different features in the power spectrum, and to perform an extensive set of experiments to understand the efﬁciency of the calibration and foreground removal algorithms. The key contribution to this program from the Melbourne node includes Pindor, Procopio, McKinley, Line, Riding at Melbourne; Trot; Wayth, Tingay at Curtin; Ofﬁnga and Briggs at ANU; Lenc and Gaensler at Sydney; and Mitchell at CSIRO)

Outreach and Professional Development Activities

The Melbourne node continued to make strong contributions in outreach, public, and professional education activities throughout 2014. Activities ranged from public lectures, to school visits, to our terrific Year Ten work-experience program; contributing stories and comments to the popular science media and general press; continuing to host international visitors to engage and collaborate with local staff and students; and providing a range of conference, seminar and training workshop opportunities to our students and early-career researchers.

In June, for example, local members of the MWA EoR team (Webster, Pindor, Riding, Line) travelled to the US for the annual MWA Busy Week held at UC Berkeley in California but organised by CAASTRO Executive Ofﬁcer, Kim Dorrell, from Melbourne. Here researchers from around the world were able to compare notes from the past year’s work in an intense but informal setting and map goals and tasks to be completed in the next year of the project.

Throughout 2014 CAASTRO afﬁliate Katie Mack continued her formidable outreach schedule. Her diverse engagements included guest speaking and panel participation at the World Science Fiction Convention followed by presenting a public lecture at Imperial College London in the UK; providing mentoring advice to young women at the “Girls on Film” festival “Girls Germs” event in Melbourne; performing in the National Science Week “Space Oddity” stage show in Sydney and Canberra; and participating in numerous national and international radio interviews, podcasts and chats with the public via Google ‘hangouts’.

As in previous years, CAASTRO continued its sponsorship of the week-long work experience program offered by the Astrophysics group which was held this year in concert with the inaugural CoEEP program. In 2014 also saw the expansion and consolidation of the Telescopes in Schools Program developed by members of the Melbourne node. In all, eleven telescopes have been installed in underprivileged schools across Melbourne and regional Victoria. CAASTRO PhD students and postdocs regularly attend schools to give talks and to help out on observing nights for the program. Coordinating both of the aforementioned activities, Jacinta den Besten successfully generated involvement in the work experience programme across the wider School of Physics, enabling more outstanding students to get a taste of a future career involving science.

Professor Stuart Wyithe

CAASTRO Node leader

Theme: Evolving (Theme Leader)

In 2014 Wyithe worked on simulations of the star-formation rate functions and stellar-mass functions of high-redshift galaxies, and on modelling the effects of environment on Ly-alpha transmission studies using numerical simulations. In 2014 Wyithe also initiated new programs to model the cross-correlation between HI and galaxies with application to the CAASTRO intensity-mapping experiment, and to perform hydrodynamic simulations of SAMI galaxies. In 2015 Wyithe will work on these new CAASTRO programs.

Professor Rachel Webster

CAASTRO Chief Investigator

Theme: Evolving

During 2014 Webster continued to manage the wider international Epoch of Reionisation (EoR) collaboration within the Murchison Wideﬁeld Array (MWA). This team is making good progress in the development of pipelines to analyse the massive EoR dataset that has been observed to date by the MWA. Webster continued her collaboration with Catherine de Burgh-Day and Edward Taylor on the Direct Shear Mapping technique, establishing that the technique is not only viable but has a high probability of being measured in local galaxies.

Ms Catherine de Burgh-Day

CAASTRO PhD student

Theme: Dark

De Burgh-Day is working on Direct Shear Mapping (DSM), a new method to measure 3D weak lensing using the velocity maps of rotating galaxies. She has fully tested the DSM ﬁtting algorithm and is currently investigating promising targets for measuring galaxy-lensing with DSM, by searching for good lens-source pairs in the Galaxy and Mass Assembly (GAMA) public data release. She plans to directly target the best of the pairs she discovers in GAMA, measure their shear, and use this to measure properties of the lens galaxies dark matter halo. She also intends to develop a non-analytic formalism for ﬂexion of a generalised lens, which unlike previous analytic derivations does not require circular symmetry in the lens. She is hoping to use this to extend DSM to include ﬂexion ﬁtting, which will allow her to probe the shape of dark matter haloes as well as their shape.

Ms Jacinta den Besten

CAASTRO Affiliate

Theme: Education and Outreach

Midway through 2014 den Besten joined the CAASTRO administration team part-time to take on the social media and outreach activities while Ebeling was on parental leave. She provided support for the Mount Burnett Observatory Astronomy Festival during National Science Week and assisted with CAASTRO’s Mid-Year Review by the ARC and the fourth Annual Retreat. In her afﬁliate role, den Besten continued implementing the Telescopes in Schools program, supported by CAASTRO for many years, and provided administration support for the expanded Year 10 work-experience program.

Ms Kim Dorrell

CAASTRO Executive Ofﬁcer

In 2014 Dorrell continued her role as node administrator, liaising with the School of Physics, Faculty of Science and central University groups to ensure the appropriate integration of Centre activities into the University’s overarching administrative structures. She also liaised with CAASTRO HQ in Sydney to ensure all reporting requirements for the node were met in an effective and timely manner. Dorrell also contributed to the burgeoning relationship between CAASTRO and the ARC Centre of

Ms Catherine de Burgh-Day

CAASTRO PhD student

Theme: Dark

De Burgh-Day is working on Direct Shear Mapping (DSM), a new method to measure 3D weak lensing using the velocity maps of rotating galaxies. She has fully tested the DSM fitting algorithm and is currently investigating promising targets for measuring galaxy-lensing with DSM, by searching for good lens-source pairs in the Galaxy and Mass Assembly (GAMA) public data release. She plans to directly target the best of the pairs she discovers in GAMA, measure their shear, and use this to measure properties of the lens galaxies dark matter halo. She also intends to develop a non-analytic formalism for flexion of a generalised lens, which unlike previous analytic derivations does not require circular symmetry in the lens. She is hoping to use this to extend DSM to include flexion fitting, which will allow her to probe the profile of dark matter haloes as well as their shape.
Mr Antonio Katsianis
CAASTRO PhD student
Theme: Evolving
Katsianis began his PhD during 2012 studying the properties of high-redshift galaxies via numerical simulation, focusing on calculating the stellar mass function and star-formation rate function from the CAASTRO suite of simulations. In 2013 he worked on interpreting what these simulations imply for the feedback mechanisms important in high-redshift galaxies. He also tested the consistency of observations from different surveys and provided evidence of tension between different groups. In 2014 he expanded this work for lower redshifts and investigated the evolution of the star formation rate–stellar mass relation. In 2015 he is focusing on submitting his thesis.

Dr Han-Seek Kim
CAASTRO Affiliate
Theme: Evolving
In 2014 Kim worked on studies to predict the 21-cm power spectrum during the epoch of reionisation using large volume dark-matter simulations such as the GigaZ and Millennium-XXL combined with a new method of making 21-cm mock observations. Additionally, he worked on the importance of the effect of reionisation on the HI mass-function of the local Universe.

Mr Jack Line
CAASTRO PhD student
Theme: Evolving
Line began working on his PhD in 2013, looking at the effects of time-averaging on interferometric data. It soon became clear that to properly probe these effects a detection of the EoR using the RTS, a good knowledge of the radio foreground sources is necessary. In 2014, Line developed PUMA, software that uses positional and spectral information to cross-match existing catalogue data and flag extended sources. In 2015 he will enhance this software and apply it in various projects, including the effects of time-averaging.

Dr Katherine Mack
CAASTRO Affiliate
Themes: Evolving, Dark
Since December 2012, Mack has been working to improve models of the evolution of the reionisation-era universe and to explore new observational avenues by investigating the effects of dark-matter particle physics. Using her theoretical expertise, Mack has formed new collaborations within CAASTRO and with members of CoEPP, aiming to connect observational and numerical projects to new theoretical developments.

Dr Ben McKinley
CAASTRO Postdoctoral Researcher
Theme: Evolving
This year McKinley completed his PhD thesis “From the Moon to the nearest radio galaxies: early science with the Murchison Widefield Array”. The thesis consisted of three refereed journal articles related to the field of low-frequency radio astronomy, the most recent of which was a multi-wavelength study of the nearby radio galaxy Fornax A. McKinley is now employed at the University of Melbourne as CAASTRO postdoctoral Researcher in EoR science. Here, he continues to be part of the MWA team and in particular contributes to the project aiming to detect the signal emitted by neutral hydrogen in the early Universe. He still maintains an interest in studying radio galaxies as well as objects in earth orbit, such as space junk and the Moon!

Ms Sinem Ozbiğen
CAASTRO PhD student
Theme: Dark
Completing her CAASTRO-sponsored MSc studies in late 2013, Ozbiğen commenced her PhD candidature at Melbourne in March 2014. She has continued her earlier work to obtain WiFiES IFU cubes of spiral galaxies from the HIcat to determine whether the velocity dispersion/circular velocity is a good indicator for galaxy type and whether it helps to reduce the scatter in the Tully-Fisher relation (TFR) as a third parameter. As this ratio does not depend on the distance of the galaxy this study could enable future inclusion of galaxies at higher redshifts in the analysis of the TFR.

Dr Bart Pindor
CAASTRO Affiliate
Theme: Evolving
Pindor is continuing his research as a core member of the MWA EoR team. In 2014, CAASTRO researchers at Melbourne, Curtin, ANU, and Sydney collaborated to create an integrated Australian-based end-to-end pipeline for processing MWA data from raw visibilities through to two-dimensional power spectra. In 2015 Pindor will use the Pawsey Centre’s Galaxy supercomputer to lead the production of power spectra from the first year of MWA EoR observations.

Dr Pietro Procopio
CAASTRO Postdoctoral Researcher
Theme: Evolving
During 2014 Procopio focused on new calibration techniques to be used in the pipeline for MWA EoR data reduction. These improvements resulted in a better handling of the noise levels in the final product, allowing a cleaner power-spectrum estimation. Procopio is also writing a pipeline for the processing of MWA GLEAM data, using the Real Time System (for calibration and peeling) and Miriad (for cleaning). This pipeline should lead to the realisation of the final phase of processing of the data, leading to what should be the definitive MWA source catalogue.

Ms Nastaran Rezaee
CAASTRO MPhil student
Theme: Evolving
In 2014, Rezaee submitted her Masters project, "Noise Characterization of Murchison Widefield Array Simulation", and will re-submit her work in March of 2015.

Mr Tristan Reynolds
CAASTRO Masters student
Theme: Evolving
Commencing with CAASTRO in July 2013, Reynold’s thesis is investigating using the Five-hundred metre Aperture Spherical Telescope (FAST), currently under construction in China, to detect quasar-generated HII regions during the EoR. He has modified the semi-numerical code for simulating the 21-cm signal from the EoR, 21cmFAST, to include quasar HII regions and added telescope and foreground noise to the simulated quasar line-of-sight 21-cm spectra. He next plans on determining what properties (HII region radius, temperature step across HII region boundary) of the HII region can be recovered from these spectra with FAST, following Gel and Wylitch (2008).

Mrs Jennifer Riding
CAASTRO PhD student
Theme: Evolving
During 2014 Riding worked on the newly commissioned MWA. ‘Shapelets’, a modelling method, was optimised for the most compact representation of a resolved source, reducing the computational requirements and keeping the RTS real time. This method is in the process of being evaluated in the RTS and early results suggest successful source subtraction allowing deeper foreground removal in our EoR fields. In 2015 Riding plans to spend time observing complex sources and then modelling them with shapelets.

Dr Edward (Ned) Taylor
CAASTRO Affiliate
Theme: Dark
Since June 2013 Taylor has been exploring a new approach to measuring the dark matter surrounding galaxies, exploiting the physical phenomenon of weak gravitational lensing. Connected to this work, he has been an active member of the SAMI Galaxy Survey team. The SAMI survey, already the largest in its class, will map the distribution and dynamics of stars and star formation within thousands of galaxies, and shed new light on the processes that drive and regulate star- and galaxy-formation.
Dr Edoardo Tescari  
CAASTRO Postdoctoral Researcher  
Theme: Evolving  
In 2014 Tescari concluded the simulation project, “The interplay between galaxies and intergalactic gas”, which was assigned a total of 5.5 Million CPU hours in three years through the CAASTRO CPU time-allocation scheme. Two papers on properties of galaxies at redshift $z \sim 4-7$ have been published in MNRAS. Two more papers are currently submitted to MNRAS. The first one is a follow up at lower redshift ($z \sim 1-4$) of the previous two papers on galaxy properties and the first author is CAASTRO PhD student Antonios Katsianis. The second is a study of both the metal and molecular content of simulated galaxy populations made in collaboration with Umberto Maiol (University of Trieste) and Ryan Cooke (University of California, Santa Cruz). Since February 2014 Tescari has been co-supervising (with principal supervisor Emma Ryan-Weber) Swinburne CAASTRO PhD student Angela Garcia on a project called “Diagnosing hydrogen reionisation with metal absorption line ratios”.

Dr Laura Wolz  
CAASTRO Postdoctoral Researcher  
Theme: Evolving  
In October 2014 Wolz joined CAASTRO to work on the theoretical modelling of HI intensity mapping surveys. She is realistically simulating the cross-correlation of optical data such as the WiggleZ galaxy survey with intensity-mapping observations. She is investigating how the joined analysis of optical and radio measurements gives insight into galaxy-evolution processes and might allow to distinguish between different star-formation scenarios. Furthermore, she will be involved into the processing and analysis of the intensity maps taken by the Parkes telescope.

In 2014 Swinburne partnered with the University of Sydney and ANU to work on making the giant Molonglo Observatory Synthesis Telescope into an extremely flexible software instrument. The first maps were made in late 2014 and allowed us to measure the flux of SN1987A again for the first time in many years and complete a map of the lobes of Fornax A. A glitch in the Vela pulsar was detected using timing data and 20 pulsars are being regularly timed using the new facility. New surveys for fast radio bursts and pulsars started at the Parkes telescope and CAASTRO PhD student Emily Petroff detected the first real-time fast radio burst using Parkes and achieved a great deal of media attention when the result was published. Dr Evan Keane was given an ongoing position with the SKA office.

In 2014 the CAASTRO cosmology group at Swinburne published new results using galaxy and velocity surveys to test the prevailing cosmological model. PhD student Andrew Johnson used the 6-degree Field Galaxy Survey peculiar-velocity dataset to test the laws of gravity on the largest scales achievable from a galaxy survey to date, measuring a scale-dependence consistent with the predictions of General Relativity. Research associate Jun Koda finalised forecasts for how these results can be extended by future velocity surveys such as Taipan and WALLABY, and was awarded a prestigious Darklight postdoctoral fellowship in Italy. Research associate Eyal Kazin published an article doubting the accuracy of the measurements of the distance–redshift relation from the WiggleZ Dark Energy Survey; Eyal has since started a job in industry.

Research associate Felipe Marin has undertaken a careful comparison of large-scale structure in the overlap regions of WiggleZ and the Baryon Oscillation Spectroscopic Survey. The group has also used an allocation of CAASTRO supercomputing time to produce a large new suite of cosmological simulations. At the end of the year, the group was boosted by the arrival of new postdoc Ilxandra Achitouv.

Chief Investigator Jeremy Mould is joint leader of a dark-matter direct-detection experiment in the Stawell gold mine. This arose from the second CAASTRO CoEPP workshop in September.

Mould commenced work with postdoctoral research fellow Elisabeta DaCunha on target selection for the Taipan Galaxy survey with the UK Schmidt Telescope at Siding Spring Observatory. This will result in the best map of local dark matter yet. Mould was successful in obtaining ARC LIEF funding for the KISS transient object survey at Dome A in Antarctica. An infrared camera will be built for a Chinese 0.85-metre telescope.

Professor Matthew Bailes  
CAASTRO Node Leader  
Theme: Dynamic (Theme Leader)  
Bailes is overseeing a project to refurbish the Molonglo Observatory Synthesis Telescope with new digital instrumentation to monitor pulsars and search for dispersed radio pulses from fast radio bursts, pulsars and rotating radio transients.

Associate Professor Chris Blake  
CAASTRO Chief Investigator  
Theme: Dark  
Blake is co-ordinating the CAASTRO Dark Theme activities at Swinburne. His CAASTRO research involves cosmological analyses and simulations of galaxy surveys to extract information from large-scale structure, gravitational lensing and galaxy velocities. He is leading a new 50-night galaxy survey at the Anglo-Australian Telescope, the 2-degree Field Lensing Survey (2dFLenS), which began in 2014. The aim of the project is to test gravitational physics through the manner in which the distribution of matter imprints both velocities to galaxies, and deflections to passing light rays. Blake and his group work on the interface of observations and theory, testing the properties of the dark energy that fills the Universe using a variety of tools such as baryon acoustic oscillations, redshift-space distortions, peculiar velocity surveys, and galaxy voids.

Professor Jeremy Mould  
Chief Investigator  
Theme: Dark  
During 2014 Mould and two CAASTRO students worked on improvements to two extragalactic distance indicators. The celebrated supernova ‘standard candle’ (Nobel Prize for Physics 2011) may be improved by measuring supernova brightness after separation into host-galaxy star-formation rate classes. The
Tully-Fisher relation for SAMI galaxies may be improved by measuring the velocity dispersion of the galaxy’s bulge as well as its rotation velocity. Luca Cortese (Swinburne) wrote an A+ Letter on this. He also co-organised the second joint CAASTRO/CoEPP workshop on direct detection of dark matter. CoEPP is interested in hosting an IFN dark-matter detection experiment looking for annual modulation from a southern hemisphere site. If an underground physics lab can be developed in the Stawell gold mine, participants in the meeting have a strong interest in organising a collaboration between CoEPP and IFN for this purpose. A working group will refine the parameters of this collaboration.

Professor Carl Glazebrook

Theme: Dark

Glazebrook’s main activity in CAASTRO has been the initiation and early development of the OzDES project, a collaboration between Australian researchers and the large international Dark Energy Survey (DES), which is carrying out a very deep large-area imaging survey of the southern sky. OzDES involves numerous CAASTRO senior investigators, and Professor Glazebrook is also engaged in the SAMI survey for quantifying the role of angular momentum in galaxy formation.

Dr Willem van Straten

CAASTRO Affiliate

Theme: Dynamic

van Straten is an expert in high-precision pulsar timing and radio polarimetry. He has developed state-of-the-art instrumentation and high-performance data analysis software for the world’s premier radio observatories and is currently leading the efforts for the Square Kilometre Array. van Straten is actively involved in the Survey for Pulsars and Extragalactic Radio Bursts (SUPERB) and the Swinburne Radio Telescope. His work continues in the areas of data acquisition, high-speed networking, real-time systems, interference excision, GPU software development and ‘big data’ management.

Dr Vikram Ravi

CAASTRO Postdoctoral Researcher

Theme: Evolving

Ravi joined CAASTRO in late 2014 to work on the UTMOST project with Professor Matthew Bailes. Ravi has been assisting with the development and commissioning of the various observing modes of this system, from making wide-angle images of the radio sky to searching for the mysterious fast radio bursts. Ravi has recently completed a PhD in Physics at the University of Melbourne, and will be taking up a Fellowship at the California Institute of Technology in September 2015.

Dr Chris Flynn

CAASTRO Postdoctoral Researcher

Theme: Dynamic

Flynn has been closely involved with the management of the Molonglo telescope project upgrade, including the GPU-based correlator and pulse-folding systems, hardware upgrades to the receivers and digitisation systems, observing scheduler and automation of observing. Significant milestones during the year include operating the telescope as an array on 25% of the antennae, producing our first maps of radio sources, the first pulsar observation using the telescope as a coherent array, detection of individual pulses from the bright pulsar Vela, full remote operations of the telescope, resuming flux monitoring of the supernova 1987A, timing of about a dozen pulsars weekly, significant progress ameliorating the effects of mobile-telephone calls, shadowing of the Parkes radio telescope when it is conducting pulsar and radio-burst surveying, and development of our pipeline system to search for individual bursts (also known as fast radio bursts, one of our primary science drivers for the upgraded instrument).

Dr Alan Duffy

CAASTRO Affiliate

Themes: Evolving, Dark

Duffy has created a new simulation series tracking the formation of the first galaxies, properties of which will be crucial for determining the viability of the Epoch of Reionisation by radio telescopes such as the Murchison Widefield Array. As well as working on the distant Universe, he has also created a bespoke online pipeline to image the local Universe from simulations in a similar fashion to ASKAP and to probe the nature of the IG M.

Mr Andrew Jameson

CAASTRO Affiliate

Theme: Dynamic

Jameson is highly experienced in software development, systems administration, high-performance computing and scientific visualisation. He has implemented several generations of pulsar instrumentation at the Parkes Radio Telescope. His work continues in the areas of data acquisition, high-speed networking, real-time systems, interference excision, GPU software development and ‘big data’ management.

Dr Ravi Barr

CAASTRO Postdoctoral Researcher

Theme: Dynamic

Barr has been at Swinburne since April 2013. His research expertise lies in the fields of digital signal processing, data mining and high-performance computing, particularly in the field of pulsar astronomy. Since arriving at Swinburne, Barr has led a project to develop state-of-the-art high-performance software that uses graphics processing units to enable real-time searches for binary pulsars. This work has now facilitated the first real-time accelerated pulsar and transient survey, the Survey for Pulsars and Extragalactic Radio Bursts (SUPERB), which is currently making new discoveries. The main focus of Barr’s current work is the design and development of the required instrumentation for pulsar science with the Square Kilometre Array (SKA). This includes design and development of an SKA (and also MeerKAT) pulsar timing backend at Swinburne, but also development of a real-time pulsar search backend (the first dedicated instrument of its kind) with partners in Europe. Barr’s work has also seen him involved in the re-commissioning of the Molonglo Observatory Synthesis Telescope (MOST). Here, we are working to vastly increase the scientific capabilities of the telescope, providing a world-class instrument for the discovery of fast radio bursts.

Dr Evan Keane

CAASTRO Postdoctoral Researcher

Theme: Dynamic

In 2014, Keane began the SUPERB survey at the Parkes telescope: this has the goal of discovering new pulsars and fast radio bursts. The project has already made some discoveries. As part of the project, Keane identified ways to improve search techniques for fast radio bursts and to more accurately determine their characteristic parameters. He was also part of teams that performed the first low-frequency high time resolution transient searches with LOFAR, made focused studies of individual pulsars including PSRJ1227-4853, an X-ray binary that recently transitioned to a millisecond pulsar, and worked on a neural network tool for identifying new pulsar discoveries in radio-telescope data.

Ms Emily Petroff

CAASTRO PhD Student

Theme: Dynamic

Petroff started her PhD in 2012 with CAASTRO scientists Dr Willem van Straten, Dr Matthew Bailes, and Dr Simon Johnston. Her work focuses on searching large radio surveys from telescopes like Parkes for new pulsars and exotic radio transients through single-pulse emission. Her main work this year has centered around finding fast radio bursts, which are bright, millisecond pulses believed to come from other galaxies. She found one such event in ‘real time’, and coordinated the largest international follow-up ever attempted. She will be building on this work to develop triggering and shadowing programs with international collaborators to understand more about this mysterious class of objects.

Mr Rahul Sai Poruri

CAASTRO PhD Student

Theme: Evolving

Poruri is a final year student pursuing a BS & MS in Physics degree at the Indian Institute of Technology, Madras. At the Swinburne University of Technology, Poruri worked with Professor Jeremy Mould to construct a Tully-Fisher (TF) relationship from the SAMI survey data. Over the span of two months, Poruri worked to reduce IFS data cubes to extract the H alpha emission lines and built a data set to construct the TF relationship. Poruri discovered interesting double lobed H alpha emission line profiles, a characteristic of galactic HI observations. His work was presented as a poster at the conference on ‘The Role of Hydrogen in the Evolution of Galaxies’.

Mr Fabian Jankowski

CAASTRO PhD Student

Theme: Dynamic

Jankowski commenced his PhD at Swinburne in September 2013 under the supervision of Professor Matthew Bailes, Dr Willem van Straten and Dr Evan Keane. He leads the pulsar-timing science programme at the Molonglo radio telescope and helps re-commission, debug and verify the instrument. More than a year’s worth of high-cadence data has now been taken, mainly using an automatic observing mode designed by him, with the current timing program consisting of about 16 pulsars.

Ms Shivani Bhandari

CAASTRO PhD Student

Theme: Dynamic

Bhandari is involved with transforming Australia’s largest radio telescope, the Molonglo Observatory Synthesis Telescope, into a wide-field camera capable of performing precision timing of multiple pulsars, radio-sky mapping, and searching the radio sky for fast radio bursts. The main challenges involve detection and excision of radio-frequency interference, and phasing the array to ultimately create tied-array beams and radio maps using the output of the supercomputer. Bhandari’s science goals are related to...
synthesis imaging using Molonglo, and also include the localisation of new pulsars that are being discovered at Parkes, and large-scale structure in red-shifted Hi. Bhandari is also part of the High Time Resolution Universe surveys (HTRU) and Surveys for Pulsars and Extragalactic Radio Burst (SUPERB) teams.

Mr Venkatraman Krishnan
CAASTRO PhD Student
Theme: Dynamic

Krishnan is a first year PhD student working with Professor Matthew Balle, Dr Willek van Straten and Dr Evan Keane at Swinburne University of Technology. His thesis mainly focuses on developing new instrumentation techniques for time domain astronomy. He will specifically focus on new ‘telescope generic’ ways to detect and excise radio-frequency interference which is crucial at the dawn of the SKA era. He will also develop efficient algorithms for the detection, analysis and timing of pulsars and other fast radio transients in ‘real time’, harnessing the advancements in computer science such as massively parallel computing architectures and ‘big data’ management. Krishnan will primarily use the Molonglo Observatory Synthesis Telescope (UTMOST) for his thesis, and he will help with several aspects of the refurbishment of this telescope during the initial part of his PhD. Apart from UTMOST, he will also use the MEERT in order to develop and test his techniques. Once the techniques are developed, he will use them to do high-precision pulsar timing and transient searching with the telescopes mentioned above.

Dr David Lagatta
CAASTRO Postdoctoral Researcher
Theme: Dark

In 2014 Lagatta published a study of the gravitational lens 3C220.3. He obtained high-resolution infrared spectra of galactic nuclei with the Magellan FIRE instrument. Stellar population models will be compared with these data to see if the initial mass function is bottom heavy (in excess of low-mass stars) in massive ellipticals, possibly explaining their high mass-to-light ratios.

In addition, Lagatta was also actively involved with the ODeS survey and the Uzu Astronomer in Residence scheme. In ODeS he is interested in the Strong Lensing Working Group: a team identifying and studying strong gravitational lenses in DES. With these newly discovered systems, he intends to expand upon the efforts of SHARP, a Keck project using gravitational lenses to find dwarf satellite galaxies. He has moved to Lyon to pursue this lensing work. It promises to take up a position in industry after three years as a CAASTRO Research Associate.

Dr Eyal Kazin
CAASTRO Postdoctoral Researcher
Theme: Dark

Eyal Kazin’s paper performing improved cosmological distance measurements to redshift $z = 1$, by applying reconstruction of the baryon acoustic feature to the WiggleZ Dark Energy Survey, was accepted for publication in MNRAS. In July 2014, Eyal left academia to pursue this lensing work. It promises to con

Syed A Uddin
CAASTRO PhD Student
Theme: Dark

Uddin’s PhD thesis falls within the framework of CAASTRO’s Dark theme. He is investigating the effect of host-galaxy environments on the light-curve parameters of Type Ia supernovae. Large datasets are being built from SNLS, SDSS, and CSP supernova surveys for this work. Additional datasets may come from the DES and SkyMapper surveys. With a large dataset and controlled analysis methods for photometry and SED fittings, this work has potential to improve systematic uncertainties originating from different host-galaxy properties (e.g. dust extinction) in supernovae light-curves. Understanding the force responsible for the cosmic acceleration is an important implication of this work. Uddin has been involved in the ODeS collaboration where the AAOmega spectograph on AAT is used to follow up supernova candidates discovered by DES. First year ODeS observations are finished and an article has appeared in AAObserver. Several supernova discovery-confirmation catalogs have also been published by the IAU. Uddin plans to submit his PhD thesis by the middle of 2015.

Associate Professor Emma Ryan-Weber
CAASTRO Associate Investigator
Theme: Evolving

Ryan-Weber’s research in 2014 continues to focus on metal absorption-line systems in the high redshift Universe. Two new PhD students have commenced at Swinburne on this project under her supervision. Los Angeles Garcia is collaborating with Edoardo Tescari and Stuart Wyithe on simulating metal absorption-line systems. Alex Codoreanu is working on high signal-to-noise ratio spectra of redshift 6 quasars to search for metal lines in the intergalactic medium at the conclusion of reionisation.

Dr Jun Koda
CAASTRO Postdoctoral Researcher
Theme: Dark

Koda worked on forecasting the accuracy with which future peculiar-velocity surveys may be used to test the cosmological model. In July 2014, Koda moved to the Darklight post-doctoral fellowship at the Osservatorio Astronomico di Brera after three years as a CAASTRO Research Associate.

Mr Andrew Johnson
CAASTRO PhD Student
Theme: Dark

Johnson is involved in using a number of recent cosmological measurements with a focus on the velocities of galaxies, to try to understand the origin of the current accelerated expansion of the Universe. The many different theories attempting to explain the accelerated expansion predict different structure-formation histories and consequently change the velocities of galaxies, among other things. As a result these measurements will allow the researchers to narrow down the plethora of current theories, and perhaps identify a single physical cause for this cosmic mystery.

Dr Felippe Marín
CAASTRO Postdoctoral Researcher
Theme: Dark

Marín worked in finding the dependence of the measured growth-rate of structures on the galaxy tracer used via redshift-space distortions (RSD) of the clustering pattern. Using data from the Sloan Digital Sky Survey and from the WiggleZ Dark Energy Survey, he tested systematics of current RSD models using Koda’s CDLA mock galaxy catalogs, and then applied his findings to the real data catalogs, finding concordance in the measured growth rate for both tracers and with the standard cosmological model. The results of this investigation will be sent to MNRAS in early 2015. Blake and Koda have collaborated in this research. In addition, Marín worked on measuring and analysing the biaspectrum of WiggleZ galaxies (higher-order clustering in Fourier space), which is a complementary measure of clustering that allows us to measure the growth of the Universe as a function of time. Also, using Koda’s method for generating fast N body simulations, Marín is working on generating mock catalogs for the EdGFS and for the future TAIPAN survey. These will allow us to estimate uncertainties and forecast the performance of future surveys.

Vincent Morello
CAASTRO Masters Student
Theme: Dark

Morello mainly focuses on pulsar searching and the application of machine learning to radio-astronomy data, under the supervision of van Straten and Barr. In 2014 he developed an automated machine-learning based system to analyse pulsar-search survey outputs. It can differentiate rare pulsar signals from millions of radio-frequency interference signals with high accuracy, a task previously requiring a very large amount of human intervention and time. His work contributed to the discovery of 10 new pulsars to date, including some left behind in previously searched data.

Ms Sue Lester
Node Administrator

Lester continues to support the activities of CAASTRO personnel at Swinburne. She was involved with the LST Town Hall event as well as the annual retreat. 2014 saw a year of structural and personnel changes within the University with CAASTRO now sitting within a new Faculty of Science, Engineering and Technology.
Research at the ANU node of CAASTRO spans the breadth of the Centre’s activities, with extensive links into all of the other nodes through CAASTRO’s major initiatives of SkyMapper survey science, SAMI, fast radio bursts, the OZDES project, MWA science, and transient science.

Within the Evolving Universe, we welcomed PhD student Mayuri Sathiyarayana Rao to the team. She, along with Professor Frank Briggs and Professor Ravi Subrahmanyan (Raman Research Institute), is investigating the feasibility of detecting additive spectral distortions in the cosmic microwave background arising from the epochs of cosmological hydrogen and helium recombination. ANU also welcomed Honours student Sarah Leslie, who successfully completed her degree working with the SAMI team at the University of Sydney, looking at optical and radio measures of star formation. Matthew Colless used the SAMI survey data to undertake analysis of the Fundamental Plane and other kinematic scaling relations: that work continues. Jonghwan Rhee, Frank Briggs, and Matthew Colless used deep observations from the Giant Metrewave Radio Telescope (India) and Westerbork Synthesis Radio Telescope (Netherlands) to measure the neutral hydrogen content of normal field galaxies in the redshift range 0.1 < z < 0.4; a period spanning roughly 30% of the age of the Universe. Despite looking back in time nearly four billion years in order to probe galaxies when they were forming stars nearly four times faster than they do at present, these observations show that the gas content of the galaxies has remained nearly constant over this time, implying that they are being replenished by accretion of fresh material from the intergalactic medium. Rhee completed his PhD thesis based on this work and took a postdoctoral research position at University of Western Australia.

Ben McKinley, André Oftringa and Frank Briggs participated in commissioning and calibrating the Murchison Widefield Array (MWA), to develop software to characterise and mitigate radio-frequency interference (RFI), to help design and implement software that enables calibration and imaging. McKinley completed his PhD at the ANU using MWA observations to study the extended radio lobes of the nearby radio galaxies Centaurus A and Fornax A. He also explored the possibilities for using the MWA observations for use in Epoch of Reionisation studies of neutral gas at redshift 7 to 12, when the first stars are lighting up. Oftringa built novel software for RFI characterisation and excision, as well as a novel implementation of the image deconvolution algorithm (CLEAN) that is especially efficient for the widefield imaging applications with the MWA.

Within the Dynamic Universe theme, student Manish Caleb, working with the team at Swinburne, has investigated the rates of fast radio bursts (FRBs). She is part of the team that is refurbishing the Molonglo Radio Telescope (MOST) to substantially increase its sensitivity and bandwidth. This should enable large numbers of FRBs to be discovered in 2015 and beyond. Caleb has also been investigating the measurement of the polarisation of single pulses from rotating radio transients which could then be applied to the single pulses from FRBs. This method has proven successful and was used by Petroff et al. (2014) to measure for the first time the polarisation of a real-time FRB detection.

Our Dynamic Universe work has also cut through the optical domains, with the team including Dr Fang Yuan, Dr Michael Childress, Dr Richard Scalzo, Dr Chris Wolf, and Professor Brian Schmidt overseeing activity. Scalzo has continued to refine his light-curve modelling technique for measuring masses of SNe Ia progenitors, applying it to other candidates for explosions of super-Chandrasekhar-mass white dwarfs, and for deriving the intrinsic dispersion of masses for a large sample of Type Ia supernovae. Using SkyMapper, Wolf, Yuan, and Scalzo coordinated multi-wavelength monitoring campaigns with the MWA and Kepler Extragalactic teams, searching for young supernovae and fast radio bursts and for QSO micro-variability. Dr Michael Childress led a sustained effort to spectroscopically observe a large number of supernovae throughout their evolution with the ANU-2.3m telescope, work that was combined with the optical group’s continuing participation in the Public ESO Spectroscopic Survey of Transient Objects (PESSTO) project. Childress used this work to gain insights into the explosion dynamics of Type Ia supernovae (SN Ia) from the evolution of their spectra.

Finally, within the Dynamic Universe, we have bolstered the theoretical capability of CAASTRO by welcoming Dr Ivo Seitenzahl and Dr Ashley Ruter. Seitenzahl showed that the 5.9 keV X-ray line emission from the decay of iron-55 is a promising diagnostic to distinguish between Type Ia supernova explosion models, and build hydrodynamic explosion models for optical transients, including helium-rich supernova explosion models for the faint SN Ia. Ruter worked on the theoretical formation channels of interacting binary stars that lead to transient phenomena, in particular Type Ia supernova progenitors. Her models have given further credence to the notion that many Type Ia supernovae arise from exploding white dwarfs that are less massive than previously speculated, and provided new theoretical birthrates for Type Ia supernova progenitors that arise from exploding sub-Chandrasekhar mass white dwarfs.

Within the Dark Universe, we welcomed PhD student Bonnie Zhang. Zhang is working to undertake a joint cosmological analysis between SkyMapper SN Ia and those in the existing SNLS survey (with LPNHE CAASTRO affiliates), and the new objects discovered as part of the OZDES survey. Yuan has set up and maintained the OZDES database hosted at ANU, participated in observing and data analysis and is leading the first-year survey paper. The OZDES survey, in addition to Zhang and Yuan, includes efforts by Schmidt, Childress, Scalzo, and Wolf. Within the Dark Universe, Colless helped complete the analysis of the WiggleZ survey, with two WiggleZ papers published in 2014.

**Professor Brian Schmidt**

CAASTRO Node Leader; Gender and Diversity Committee Chair

**Theme: Dark**

Schmidt continued to lead work on SkyMapper, which spent 2014 undertaking the Southern Sky Survey. More than 80% through its short survey of the Southern Sky, in 2015 the telescope’s attention will be turned to extending the survey to fainter limits. In 2014 Schmidt continued to oversee the software pipelines, with these expected to produce data for the wider CAASTRO community in 2015. A decision was made to postpone a major supernova survey with the telescope until 2015, but many reference frames (required for supernova detection) were taken. Schmidt continues to make many public appearances both in Australia and internationally, including being a keynote speaker at the World Economic Forum in Davos, the Eurosience Open Forum (ESOF) in Copenhagen. The European Space Agency’s 50th Anniversary Celebration, as well giving major lectures in New York City USA, Tokyo Japan, Groningen Netherlands, and Marz.

Germany. In November, along with his High-Z Supernova Search Team Supernova Cosmology Project colleagues, he received the 2015 Breakthrough Prize in Physics in a ceremony held in Silicon Valley.

**Professor Frank Briggs**

CAASTRO Chief Investigator

**Themes: Evolving, Dynamic**

Briggs’ research interests have focused on the use of the radio 21-cm line of neutral hydrogen to follow the history of galaxy formation and evolution. Atomic hydrogen is the most primitive and most common of the elements, and primordial clouds of hydrogen gas are the substance from which the visible components of the structure of the Universe (the stars and galaxies) form. Briggs has been a member of the MWA Consortium to design, build and operate the Murchison Widefield Array in Western Australia since the project’s conception. He has also been engaged in an ongoing collaboration with Indian astronomers at the National Centre for Radio Astrophysics in Pune and with astronomers within Australian institutes to use the Giant Metrewave Radio Telescope (GMRT) to measure the evolution of the gas content of galaxies over the last seven billion years, and the role of the gas to star-forming properties of galaxy populations.

**Professor Matthew Colless**

CAASTRO Chief Investigator

**Themes: Evolving, Dark**

Colless led the 6dF Galaxy Survey that used the UKST to map the density and velocity fields in the local Universe by measuring Fundamental Plane distances and peculiar velocities for 10,000 nearby galaxies. He brings this expertise to the WALLABY survey team, which will test the current cosmological paradigm that the distributions of dark and luminous matter are the same on the largest scales by combining the WALLABY all-sky neutral hydrogen survey using ASKAP with an all-sky optical survey using SkyMapper. Colless is engaged in the comparison of the radio and optical surveys and the analysis of the velocity field and its implications for cosmological models. The CAASTRO research program brings together the WALLABY and FLASH ASKAP surveys with the 6dF and the proposed TaPAN UKST survey to investigate the most distant galaxies.

Finally, by engaging with the Public Engagement & Communication team, Colless plans to study the co-evolution of gas and stars out to a redshift z ~ 0.25 using the WALLABY
ASKAP radio surveys to measure the neutral hydrogen gas component of galaxies and the UKST optical spectroscopy to measure the stellar component.

Dr Fang Yuan  
CAASTRO Postdoctoral Researcher  
Theme: Dynamic  
Yuan is a member of the SkyMapper transient team. The SkyMapper transient search found its first supernova in late 2013 and is expected to have a steadily increasing discovery rate as the survey area expands and the pipeline continues to be improved. Her main science interest involves understanding of a diverse range of stellar explosions. She studies core-collapse supernovae and is responsible for coordinating SkyMapper and the ANU 2.3-m to follow up gamma-ray bursts, fast radio bursts and gravitational-wave candidate events. Yuan is also a member of the OzDES team. In addition, she is running the “CAASTRO in the Chinese Classroom” outreach program.

Dr Michael Childress  
CAASTRO Postdoctoral Researcher  
Theme: Dark  
Childress’ research focuses on observations of nearby supernovae, particularly through optical spectroscopy. In 2014 Childress had three papers published: one on high-velocity features in spectra of Type Ia supernovae (accepted in 2013), one describing the data-reduction pipeline for the WiFeS instrument (accepted in 2013) and one on ages of Type Ia supernovae as a function of galaxy environment and cosmic time. Childress is the Theme Scientist for the Dark theme, and is a member of the OzDES, 2dFLenS surveys.

Dr Andre Offringa  
CAASTRO Postdoctoral Researcher  
Theme: Dynamic, Evolving  
Offringa joined CAASTRO in 2012 as postdoctoral fellow at ANU. He is part of the Epoch of Reionisation team that uses the Murchison Widefield Array (MWA) to detect faint redshifted Hi signals from a yet unseen era of our Universe. The MWA radio telescope will generate huge data volumes, and processing these efficiently is an exciting challenge. Offringa works on efficient algorithms that are required for processing these data. He is also involved in the analysis of observations for the Epoch of Reionisation to investigate the properties of foreground sources, and works on the mitigation of radio-frequency interference (RFI).

Dr Richard Scalzo  
CAASTRO Associate Investigator  
Themes: Dark, Dynamic  
Scalzo’s research focuses on observational studies of supernovae at optical wavelengths, with emphasis on Type Ia supernova progenitors and explosion physics. Scalzo published three papers in 2014 on the diversity of ejected masses in Type Ia supernovae, including (with CAASTRO Associate Investigators Stuart Sim and Ashley Ruiter) the first detailed distribution of ejected masses for a large sample of Type Ia supernovae used in dark energy experiments. These results suggest that progenitor-mass variation plays an important role in explaining the empirical relations used to standardise supernova distances for cosmology, and have been featured in science media, talks at two international conferences, and invited seminars in Australia and the United States. Scalzo continues to build new collaborations with theorists and observers to work on supernova progenitors, with the goal in 2015 of creating a robust Bayesian inference framework for progenitor properties of massive star explosions. Together with colleague Dr Fang Yuan, Scalzo has also continued development and operation of SkyMapper’s Supernova Search, including coordinated observations with the Kepler Extra-Galactic Survey (KEGS) and the Murchison Wide-Field Array to search for supernovae and fast radio bursts. The Supernova Search also discovered and confirmed SN 2013hx, a rare, superluminous Type Ic supernova. The Supernova Search will begin taking data at full scale for its Type Ia supernova cosmology project in early 2015.

Dr Christian Wolf  
CAASTRO Associate Investigator  
Theme: Evolving, Dark  
Wolf started work as SkyMapper Survey Scientist in April 2013 and currently works on optimising operations, preparing survey data releases, and helping third-party users to make best use of the telescope. He previously led the COMBO-17 optical multi-band survey, which explored the evolution of galaxies and quasars over most of cosmic time. He is an expert in photometric redshift and statistical classification techniques and pioneered high-precision photometric redshifts and their application to quasars. His research interests include galaxy evolution and the decline of star formation in spiral galaxies as well as supernovae, GRBs and their host galaxies. His most recent work focused on the transformation of spiral galaxies in clusters and the effects of ram-pressure stripping.

Dr Robert Sharp  
CAASTRO Associate Investigator  
Theme: Evolving, Dark  
Sharp is instrument scientist for the Giant Magellan Telescope Integral Field Spectrograph, a new instrument under design at the Australian National University and destined for the Giant Magellan Telescope in Chile in 2021. Within CAASTRO Sharp is a leader of the SAMI Galaxy Survey data analysis group, for which the SAMI survey team delivered the first public data release in July 2014. For the OzDES supernova survey project (which completes the second full year of its five year campaign in early 2015), Sharp is the local coordinator for the ‘reverberation mapping’ component that will measure the masses of giant black holes in distant quasars. Additionally, Sharp has teamed up with radio astronomers interested in faint radio galaxies and is using the repeated visits to the OzDES supernova surveys to record sensitive observations of these enigmatic galaxies to identify the underlying source types and their distances from Earth.

Dr Ashley Ruiter  
CAASTRO Associate Investigator  
Theme: Dynamic  
Ruiter works in binary star evolution modelling to understand the formation of interacting stars that give rise to explosive phenomena. She is interested in transient sources involving white dwarfs (e.g., Type Ia supernovae), and uses theoretical methods to uncover the evolutionary channels that lead to their formation, predict their birth rates, and constrain their birth sites (ages). Ruiter has been a member of CAASTRO since 2013 and joined the ANU in April 2014.

Dr Ivo Seitenzahl  
CAASTRO Associate Investigator  
Theme: Dynamic  
Seitenzahl became a CAASTRO Associate Investigator in October 2013 and joined ANU as a SkyMapper Fellow in April 2014. He is a theoretical nuclear astrophysicist and his research focuses on explosive nucleosynthesis and three-dimensional simulations of Type Ia supernova explosions. Seitzenzahl’s research also includes work on the formation and propagation of detonations powered by nuclear fusion, the Galactic chemical evolution of manganese, the atomic and nuclear physics of late-time supernova light-curves, and the detectability of the 5.9 keV X-ray line emission from the decay of 56Fe in thermonuclear supernovae.

Ms Sharon Rapport  
CAASTRO PhD Student  
Theme: Dynamic  
Rapport joined CAASTRO’s ANU team as a PhD student in 2011. She worked on studying the expected angle-dependent synthetic spectra from jet-driven models (using Stuart Sim’s 3D radiative transfer code) to better understand the observational expectations from gamma-ray bursts associated with supernovae, and constrain physical phenomena of the explosions properties by studying their observational consequences. She submitted her thesis in August 2014.

Ms Manisha Caleb  
CAASTRO PhD Student  
Theme: Dynamic  
Caleb began her PhD in July 2013 under the supervision of Frank Briggs at ANU and Matthew Bailes and Chris Flynn at Swinburne. ‘Fast radio bursts’ (FRBs) are bright, coherent, millisecond-duration radio emission of unknown origin thought to occur at cosmological distances. Only a handful of these sources have been discovered to date. When more sources are discovered they could potentially help unveil some of the mysteries of the cosmos. Caleb is part of the team at Swinburne that is taking part in the worldwide race to discover more of these exciting sources.

Caleb is also performing Monte Carlo simulations to determine the discovery rates of these FRBs at the Parkes and Molonglo radio telescopes. The Molonglo radio telescope, a interferometer near Canberra, is currently being collaboratively refurbished with state-of-the-art backend technology to transform it into a burst-detection machine. When fully recommissioned, the telescope will be able to detect events four times better than Parkes.
Ms Bonnie Zhang  
CAASTRO PhD Student  
Theme: Dark, Dynamic  
Zhang began her PhD in February 2014 under the supervision of Brian Schmidt. Her research is in observational cosmology with Type Ia supernovae, with the goal of constraining dark energy. As part of both the SkyMapper team and the OzDES collaboration, she will analyse light curves of supernovae discovered in the SkyMapper Supernova Survey, at low redshift, and the Dark Energy Survey, at high redshift. She will also compare the photometric calibrations of both surveys to quantify and minimise the systematic uncertainty associated with the calibration.

Ms Mayuri Sathyanarayana Rao  
CAASTRO PhD Student  
Theme: Evolving  
Sathyanarayana Rao began her PhD in March 2014 under the supervision of Frank Briggs at ANU and Ravi Sathyanarayana Rao. Her research is in observational cosmology with Type Ia supernovae, with the goal of constraining dark energy. As part of both the SkyMapper team and the OzDES collaboration, she will analyse light curves of supernovae discovered in the SkyMapper Supernova Survey, at low redshift, and the Dark Energy Survey, at high redshift. She will also compare the photometric calibrations of both surveys to quantify and minimise the systematic uncertainty associated with the calibration.

Ms Sarah Leslie  
CAASTRO Pre-PhD Student  
Theme: Evolving  
In 2014 Leslie completed her Honours in Astronomy and Astrophysics at ANU under the supervision of Professor Lisa Kewley, and of the University of Sydney CAASTRO members Professor Elaine Sadler and Dr Julia Bryant. Leslie works with the SAMI galaxy survey, and her thesis involved combining the optical data from SAMI with radio-continuum data from the VLA FIRST survey. Aiming to better understand radio emission in star-forming galaxies, Leslie found that shocks could play an important role in enhancing radio emission in galaxies with large-scale winds.

Ms Denise Sturgess  
CAASTRO Administrator  
Sturgess has worked as CAASTRO Node Administrator at the Australian National University, Mt Stromlo Observatory, since CAASTRO’s inception. She provides ongoing, broad administrative support to the team and works alongside Chief Investigator Professor Brian Schmidt as his assistant.

It has been an exciting year for UQ astrophysics, as 2014 saw us becoming a new node of CAASTRO. Being part of the CAASTRO community has had a tangible impact on our group, particularly our students, and helped us build on our existing collaborations and establish new ones.

Research at the Queensland node focuses on the Dark and Evolving themes. In September we welcomed our new CAASTRO postdoctoral fellow, Edward Macaulay, who is working on measuring the lensing magnification of supernovae in the OzDES survey. This should improve the precision with which the supernovae can be used as standard candles, and also allow for the amplitude of density fluctuations to be measured from signals in the data that would previously be considered as noise.

Macaulay has a background in peculiar velocities, and so will be working also with students for our peculiar-velocity projects.

David Parkinson has been drilling into non-standard cosmologies: in particular, he has made the first predictions for what large-scale structure should look like in Galactic cosmologies. These models have an extra degree of freedom, which may have stochastically independent initial conditions that can break complete correlation between density and velocity power spectra, and thus make interesting testable predictions. Meanwhile his Honours student Caitlin Adams has investigated the effect neutrinos would have on power spectra, using a combination of COLA simulations made by our CAASTRO colleagues in Swinburne and emulator techniques to fill in the gaps between models that were able to be simulated. Adams has now moved on to a PhD at Swinburne.

Despite the fact that Signe Riemer-Sorensen has moved to the University of Oslo, we continue our active collaboration and co-supervision of students with her. In 2014 we published the strongest neutrino mass constraint to date from cosmology based on Planck observations of the cosmic microwave background combined with the galaxy power spectra from Wiggles. The analysis also provided interesting information on the neutrino hierarchy. In related work Signe performed a case study for improving measurements of the primordial deuterium abundance in order to constrain the presence of beyond-standard-model physics around the time of Big Bang nucleosynthesis; and following the detection of a 3.6 keV emission line in stacked galaxy-cluster spectra by Bulbul et al. (2014), she performed a search for line emission from the Milky Way, which disproved the speculated dark-matter origin of the galaxy-cluster line.

Michael Drinkwater continues to work on SAMI science, and student Adam Thomas completed his Honours thesis on searching for ram-pressure stripping in galaxy clusters with SAMI. While no definite cases of ram-pressure stripping were present in his sample, he did find strong evidence for a trend of increasing gas ionisation with distance from the nucleus in several galaxies. Continuing our close CAASTRO ties, Adam has moved on to a PhD at ANU. Michael was also awarded a prestigious teaching fellowship at UQ to develop his innovative teaching methods.

The Type Ia supernova rate has been looked at in an unusual way by Holger Baumgardt who quantified the role that direct collisions between white dwarfs may play. He and his student Lara Cullinane simulated collision rates between single white dwarfs in various globular clusters, and also investigated the role of stellar binaries for these collisions.

Tamara Davis’ work has focused on OzDES this year, with our second year of observations now complete. She worked with software engineering Honours student Samuel Hinton, who rewrote the 2dF redshifting software, making it much easier to use and more powerful, while being accessible from a web browser without needing any complex installation. Sam won several awards for his thesis including the Institute of Electrical and Electronics Engineers student thesis award and the GroundProbe Prize Award for best thesis in photonics, microwave and communications. Meanwhile Honours student Corin O’Neill completed a simulation of the efficiency of our OzDES strategy of re-observing supernova host galaxies until we obtain a successful redshift. He is currently in Chile on a Gemini studentship. Davis also wrote a non-technical review of Cosmological Dark Energy constraints for General Relativity and Gravitation.

It was our great pleasure to be the host node for the annual CAASTRO retreat at the Sunshine Coast in November and, earlier in the year, the OzDES busy week. We spoke about our CAASTRO research at numerous conferences worldwide, including the Aspen workshop on cosmology, the CoEPP-CAASTRO workshop on direct dark matter detection, the Dark Energy Survey collaboration meetings in Chicago and University of Illinois, and the Academy of Science Frontiers of Astronomy conference in Canberra.
Dr Holger Baumgardt
CAASTRO Affiliate
Theme: Dynamic
Baumgardt’s focus is on the role that direct collisions between white dwarfs play in determining the overall supernova Type Ia rate in galaxies. In 2014, he and a student worked on calculating collision rates between single white dwarfs in various globular clusters. He also did simulations to investigate the role of stellar binaries for these collisions.

Dr Edward Macauley
CAASTRO Postdoctoral Researcher
Theme: Dark
Macauley’s main research interest is testing fundamental physics with cosmological surveys, with a particular focus on understanding dark matter and dark energy with galaxy surveys. He is currently working on measuring the lensing magnification of supernovae in the OzDES survey. This should improve the precision with which the supernovae can be used as standard candles, and also allow for the amplitude of density fluctuations to be measured from signals in the data that would previously have been considered as noise.

Dr Signe Riemer-Sørensen
CAASTRO Affiliate
Theme: Dark
In 2014 Riemer-Sørensen published the strongest neutrino mass constraint to date from cosmology based on Planck observations of the cosmic microwave background combined with the galaxy power spectrum from WiggleZ. The analysis also provided interesting information on the neutrino hierarchy. She also did a case study for improving measurements of the primordial deuterium abundance in order to constrain the presence of beyond-standard-model physics around the time of Big Bang nucleosynthesis. Furthermore, following the detection of a 3.5 keV emission line in stacked galaxy cluster spectra by Bulbul et al. 2014, she performed a search for line emission from the Milky Way, which disproved the speculated dark-matter origin of the galaxy-cluster line.

Ms Caitlin Adams
CAASTRO Honours Student
Theme: Dark
Adams completed her Honours research in 2014, and was jointly supervised by Dr David Parkinson and Associate Professor Chris Blake. The project covered the construction of an emulation pipeline that could be used to estimate a galaxy power spectrum from a limited set of N-body simulation power spectra. This extended on previous emulation work by including a neutrino mass parameter. As a part of the project, the pipeline was incorporated into CosmoMC, and the WiggleZ power-spectrum data was used within this framework to constrain the neutrino mass. Her results indicated that the emulation approach could be used to provide strong constraints on cosmological parameters while reducing the computational cost by using fewer N-body simulations.

Mr Sam Hinton
CAASTRO Honours Student
Theme: Dark
Hinton completed his software engineering thesis under supervision of Professor Tamara Davis in 2014, where his project, Marz, was to provide the OzDES team a more efficient and advanced redshifting tool. Hinton has explored the limits of current standards and technology by implementing the program entirely as a client based web application, allowing complete platform independence. The web application is currently in ‘open-beta’, and Hinton intends to continue development whilst undertaking science honours as a CAASTRO student in 2015.

Ms Anthea King
CAASTRO PhD Student
Theme: Dark
King is investigating whether active galactic nuclei (AGN) are useful and viable standard candle candidates using a technique called reverberation mapping (RM). It is her hope that we can use them to help constrain the properties of dark energy, as well as giving insight into galaxy–black hole coevolution. King is involved in OzDES, which will regularly monitor 500 AGN over its five year duration, allowing a RM investigation. Her current work concentrates on predicting the expected performance and scientific output of the OzDES RM project as well as testing the most efficient survey extensions and optimal target selection.

Mr Conor O’Neill
CAASTRO Honours Student
Theme: Dark
O’Neill is a member of OzDES and has been working to optimise the observation strategy of the survey in order to maximise the number of redshift measurements, and therefore science results, that OzDES obtains. As part of his thesis he also investigated the effectiveness of SNe and BAO as measurement probes in the constraints they place on cosmological parameters. O’Neill’s supervisors are Tamara Davis and Chris Lidman.

Mr Adam Thomas
CAASTRO Honours Student
Theme: Evolving
Thomas completed an honours project in 2014 under the supervision of Michael Drinkwater. His research made use of 2D spectral data from the SAMI Galaxy Survey to try to identify signs of ongoing ram-pressure stripping in cluster galaxies. He will continue to study galaxy evolution in a PhD in 2015.

Ms Sarah Thomson
CAASTRO Honours Student
Theme: Dark
Thomson has undertaken a project to determine whether it is possible to detect a suppression at large scales in the primordial power spectrum with galaxy surveys. Her project supervisors are Dr David Parkinson and Professor Ray Norris.

Ms Candy Wu
CAASTRO Administrator
Wu joined the CAASTRO UQ node in March 2014, having worked for School of Maths and Physics and School of Business at UQ in finance and HR for five years. Wu provides financial and administrative support to the CAASTRO members at UQ, and is responsible for reconciliation of financial data against the CAASTRO budget.
CAASTRO LINKAGES

CAASTRO has very strong national and international linkages through a substantial network of high-performing Australian and overseas researchers who participate in one or more of CAASTRO’s three research themes. These carefully selected Partner Investigators offer some of the strongest scientific track records in international astronomy, with proven performance in the successful execution of large radio projects, and are from world-class institutions including the Australian Astronomical Observatory, CSIRO, Oxford, Caltech and the Max Planck Institutes. Our international Partner Investigators are not only active participants in research studies with Australian telescopes but also enhance these efforts by contributing results and techniques from major international projects. We also have Associate Investigators and Affiliates from our Partner Organisations.

The Australian Square Kilometre Array Pathfinder telescope combined with the Murchison Widefield Array, SkyMapper, the Square Kilometre Array Molonglo Prototype and the Pawsey High Performance Computing Centre for SKA Science, Australia’s large investments in wide-field technologies and in high-performance computing will enable CAASTRO to create a world-leading research programme.

Along with the world-class team of CAASTRO researchers across our nodes based at Australia’s highest-ranked universities and fast-growing centres of Australian astronomy, bringing together this expertise in radio astronomy, optical astronomy, theoretical astrophysics and data science will enable CAASTRO to reach its vision of being an international leader in wide-field astronomy.

Partner Organisations

Australian Astronomical Observatory

Professor Warrick Couch
CAASTRO Partner Investigator

As Director of the Australian Astronomical Observatory, Professor Couch has a significant role in supporting the operations and management of CAASTRO as the AAO is providing some of the Centre’s key facilities, through the wide-field optical spectroscopic capabilities of the Anglo-Australian Telescope (AAT) and the UK Schmidt Telescope (UKST). Of particular importance are the SAMI Galaxy Survey being operated by a history of ARC and Industrial Commissions. Professor Couch is a member of the CAASTRO Science and Technology Committee.

Dr Chris Lidman
CAASTRO Associate Investigator

Dr Lidman is an Associate Investigator in CAASTRO, and his role is in the Dark Universe theme, where he contributes to the follow-up of Type Ia supernovae discovered by SkyMapper and the Dark Energy Survey. His expertise is in observational cosmology, Type Ia supernova, galaxy clusters, primordial galaxies, and exotic transient phenomena. Lidman is an expert in adaptive optics, near-infrared imaging and optical spectroscopy.

Dr Irakis Konstantopoulos
CAASTRO Affiliate

Dr Irakis Konstantopoulos is a CAASTRO Affiliate working in the Evolving Universe theme. Through his involvement in the SAMI Galaxy Survey he is revising the technological methodology of astronomical data archiving, and through his work on galaxy groups he aims to identify the ‘glue’ that keeps galaxies together, and which accelerates their evolution when they are at close quarters. Irakis is an expert on two- and three-dimensional spectroscopy and an exponent of the astrophotonics movement.

Commonwealth Scientific and Industrial Research Organisation

Dr Brian Boyle
CAASTRO Partner Investigator

Dr Brian Boyle is the Acting SKA Director for the Department of Industry, following his role as CSIRO SKA Director. Previously, he was the Director of the CSIRO Australia Telescope National Facility (2003–2009) where he initiated the construction of ASKAP, and Director of the Anglo-Australian Observatory (1998–2003). His main research interests are cosmology, active galactic nuclei and quasars. During his career he has overseen the successful commissioning of world-class instruments and has led many international scientific collaborations. He has been a Fellow of the Australian Institute of Company Directors since 2005. As Chairman of the National Committee for Astronomy, he led the development of the Decadal Plan for Australian Astronomy 2006–15. He was also the facilitator for the NCRIS investment plan for optical and radio astronomy.

Dr Simon Johnston
CAASTRO Partner Investigator

Dr Johnston is Head of Astrophysics for CSIRO Astronomy and Space Science. His interests include pulsars, radio transients and Extreme Scattering Events and are thus closely aligned with the Dynamic Universe theme. He is a key member of the VAST survey project and is a member of the Pulsar Science Working Group for the SKA.

Professor Ray Norris
CAASTRO Partner Investigator

Professor Norris has recently retired as the Chief Research Scientist within CSIRO Astronomy and Space Science, and Project Leader for EMU (Evolutionary Map of the Universe), one of the two key projects (the other being WALLABY) that were selected to drive the design and construction of ASKAP. EMU is an all-sky continuum survey that lies within CAASTRO’s Evolving Universe theme, with its primary goal being to trace the origin and evolution of galaxies over cosmic time. EMU will also have a major impact on characterising Dark Energy and Modified Gravity, aligning it with the Dark Universe theme.

Dr Keith Bannister
CAASTRO Affiliate

Dr Bannister is an Affiliate in CAASTRO. His role in the Dynamic theme is in modelling fast radio bursts, following-up astronomical transients at radio wavelengths and radio transients surveys. His expertise is in radio data processing, radio transients and archival searches.

Dr Antonia Rowlinson
CAASTRO Affiliate

Dr Antonia Rowlinson is an Affiliate in CAASTRO and her role is in the Dynamic Universe theme contributing to the search for slow transients and fast radio bursts, typically using low-frequency radio images from the Murchison Widefield Array. Her expertise is in the analysis of radio-transient and variability surveys using automated imaging and analysis pipelines, using multi-wavelength data to constrain the progenitors of short gamma-ray bursts and the magnetar central-engine model for short gamma-ray bursts.
University of Arizona, USA

Professor Xiaohui Fan
CAASTRO Partner Investigator

Professor Fan’s primary involvement in CAASTRO science is within the Evolving Universe theme. He is renowned for his expertise in the discovery of high-redshift quasars, and more generally in the use of all-sky surveys to discover rare objects, especially valuable for the Skymapper survey’s search for high-redshift quasars.

Max Planck Institute for Extraterrestrial Physics, Germany

Dr Mara Salvato
CAASTRO Partner Investigator

Dr Salvato works in the High Energy Group and is a member of the eROSITA team. eROSITA is an X-ray satellite which is soon to be launched and will map the entire sky. As a Partner Investigator Salvato promotes collaboration between CAASTRO and eROSITA and leads project groups enhancing the synergy between X-ray, Radio and Optical surveys of AGN.

University of Durham, USA

Professor Carlos Frenk
CAASTRO Partner Investigator

Professor Frenk’s contributions to CAASTRO are under the themes of the Evolving and Dark Universes. Over the coming decade, CAASTRO will observe the moderate redshift neutral hydrogen Universe for the first time via the ASKAP FLASK, WALLABY and DINGO surveys. For this reason it is important to take stock of what theoretical galaxy formation models tell us about the abundance and distribution of HI in the Universe. Frenk, as the head of the Institute for Computational Cosmology and joint lead investigator on the Millennium simulation (the largest simulation of the Universe ever undertaken), is in a unique position to contribute the theoretical galaxy formation models that will be needed to exploit CAASTRO’s scientific observations.

Max Planck Institute for Radio Astronomy, Germany

Professor Michael Kramer
CAASTRO Partner Investigator

Professor Kramer’s research activities are under the Dynamic Universe theme of CAASTRO. His focus is on the exploration and exploitation of the dynamic radio sky, both in the study of pulsars as well as new types of transients, allowing CAASTRO to address a wide range of astrophysical questions, ranging from the state of matter at extreme densities, to cosmology and tests of theories of gravity. The enabling process on the exploration and exploitation of the dynamic radio sky, both in the study of pulsars as well as new types of transients, allowing CAASTRO to address a wide range of astrophysical questions, ranging from the state of matter at extreme densities, to cosmology and tests of theories of gravity. The enabling process

Max Planck Institute for Radio Astronomy

For Radio Astronomy

Max Planck Institute

Raman Research Institute

Bangalore

University of Oxford

Professor Roger Davies

University of Oxford

Professor Roger Davies was until recently Head of Astrophysics at Oxford University. Within CAASTRO, Davies’s contribution will be primarily in the Evolving Universe theme and the SAMI project. His research interests include cosmology: the distance scale, large scale motions of galaxies and galaxies at high redshift; galaxy evolution: dynamics, stellar populations and galaxy clusters; and telescopes, instruments and techniques.

University of London

Dr Stuart Sim

CAASTRO Associate Investigator

Dr Sim’s research focuses on the theory of supernova explosions. In particular, he works on developing models for Type Ia supernovae, the events that are used as ‘standard candles’ to map out the expansion history of the Universe. He is also working with CAASTRO student alumnus Sharon Rapoport on new studies of bipolar supernovae, the class of explosion associated with gamma-ray bursts. Such theoretical modelling is an important part of understanding and interpreting observations taken as part of the next generation of astrophysical transient surveys, such as will be carried out with the SkyMapper telescope.

University of Cambridge

Dr Greg Madsen

CAASTRO Affiliate

Dr Greg Madsen is an Affiliate in CAASTRO within the Dynamic Universe theme. He is contributing to the interpretation of Fast Radio Bursts and is using historical plate archives to discover new populations of long term variable stars and quasars. His expertise is in the interstellar medium, planetary nebulae, and variable stars. He is an expert in Fabry-Perot spectroscopy and optical/near-IR imaging.

Associated Organisations

University of Nottingham

Dr Jamie Bolton

CAASTRO Associate Investigator

Dr Bolton is an Associate Investigator in CAASTRO and he is currently a Royal Society University Research Fellow and lecturer at the University of Nottingham, a position he has held since October 2012. In 2014 he completed work with former CAASTRO PhD student Brad Greg on developing simulations to calculate the effect of temperature fluctuations on Lyman-alpha absorption statistics towards quasars. He also examined the impact of high mass X-ray binaries on the ionisation state of the intergalactic medium, in collaboration with CAASTRO Associate Investigator Professor Chris Power (UWAI) and researchers at the University of Leicester.

University of Birmingham

Dr Stuart Sim

CAASTRO Associate Investigator

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University of Oxford

Professor Roger Davies

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National Computational Infrastructure

Professor Lindsay Botten

CAASTRO Partner Investigator

As Director of National Computational Infrastructure, Professor Lindsay Botten is supporting CAASTRO’s access and usage of NCI’s high-end computing services across all of CAASTRO’s three themes and from all nodes. In 2014, some 8 million CPU hours were utilised.

University of Cambridge

Dr Greg Madsen

CAASTRO Affiliate

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Internationally during the course of 2014, including the following:

- CAASTRO team members have been involved in a number of collaborations with institutions both in Australia and internationally during the course of 2014, including the following:

  **eROSITA**

Institutions: Max-Planck-Institut für Extraterrestrische Physik, CAASTRO

The extended ROentgen Survey (eROSITA) is an instrument on the Russian Spektrum-Rötgen-Gamma (SRG) satellite, to be launched in 2015. eROSITA will perform an X-ray survey of the entire sky with unprecedented angular resolution and sensitivity. The German eROSITA consortium (eROSITA_DE) and CAASTRO have signed a memorandum of understanding that enables eROSITA_DE and CAASTRO to combine the eROSITA survey with the CAASTRO SkyMapper survey of the southern sky, providing Australian astronomers with a powerful and efficient multi-wavelength astronomy project. While eROSITA is owned and operated by the Research School of Astronomy and Astrophysics at ANU, CAASTRO has received 91.16% of ARC LEIF funding to secure membership of the SkyMapper consortium for all Australian astronomers from 2014-2019. This contributes to the operations costs needed for SkyMapper to undertake a 5-year survey of the entire southern sky, provides Australian astronomers with 20% of non-survey observing time on SkyMapper, and there is substantial CAASTRO involvement in all these programs. CAASTRO has made new opportunities for multi-wavelength astronomy projects across the southern sky.

**SkyMapper Supernova Search**

Institutions: HEP-Paris VI, Australian National University, OZDES Collaboration, PESSTO Collaboration

Among the core goals of SkyMapper is a nearby supernovae survey. Working with the European PESSTO collaboration, the SkyMapper Supernova Search is obtaining spectra of all of the survey’s discoveries to a limiting magnitude of g = 19. A principal survey aim is to produce a nearby SN sample comparable in quality to those gathered by the Supernova Legacy Survey and the Sloan Digital Sky Survey. As part of the collaboration, The SkyDice (SkyMapper Direct Illumination Calibration Experiment) system – a dedicated photometric calibration device was installed in the SkyMapper enclosure. The ANU-HEP collaboration aims to provide the photometric datasets that minimise the systematic error components on SN ia distances, and thereby provide a substantial improvement on the measurements of the Dark Energy equation of state parameter. The SkyMapper Supernova Search is also working as part of the O2-DES Collaboration to combine the nearby SN dataset with the High-Z SN Dataset from the DES Survey. The Search made its first discoveries in 2013, and should continue to discover more than 50 objects per year.

**S-PASS**

Institutions: CSIRO, Max-Planck-Institut für Kernphysik, Australian National University, The University of Sydney, ICRAR / University of Western Australia, Radboud University Nijmegen, Leiden University, Harvard-Smithsonian Center for Astrophysics, INAF-Osservatorio Astronomico di Cagliari

The S-band Polarisation All Sky Survey (S-PASS) has used the Parkes radio telescope to map the polarised emission from the entire southern sky at a frequency of 2.3 GHz and a resolution of nine arcminutes. The goal of S-PASS is to understand the foreground polarised emission from the Milky Way, and to then model and remove it for studies of the polarisation from the cosmic microwave background. The S-PASS team has reported the discovery of polarised emission from the ‘Fermi bubbles’ emanating from the centre of the Milky Way, and the detection of a synchrotron radio bridge in the galaxy cluster Abell 3667.

**TAIPAN**

Institutions: AAO, Australian National University, CSIRO, Macquarie University, Monash University, Swinburne University of Technology, University of Melbourne, University of New South Wales, University of Queensland, The University of Sydney, University of Western Australia, University of Western Sydney

TAIPAN is a new facility for the UK Schmidt Telescope at Siding Spring Observatory. It encompasses a novel optical fibre positioner using the new ‘starbugs’ technology, a purpose-built spectrograph, and refurbishment of the UKST itself. Funding for the facility is now available, and construction of the positioner and spectrograph has begun, together with the telescope refurbishment. The TAIPAN facility will support two major new surveys. (1) The TAIPAN survey of half a million galaxies aims to make a 1% precision measurement of the Hubble constant, H₀, and measure the bulk motion of galaxies to better understand large-scale structure, Dark Matter and gravitation. Together with the WALLABY survey using ASKAP, it will link the star-formation and gas-fuelling properties of galaxies to better understand galaxy evolution and formation. (2) The Funnelweb survey plans to measure two million stars within our Milky Way Galaxy, uniquely characterising them and complementing the fainter GALAH Galactic Archaeology survey, as well as providing a robust input sample for the next-generation planet-finding satellite observatory, TESS. The TAIPAN surveys will begin in early 2016, with preliminary observations during commissioning activities in late 2015. While the scientific plans for the TAIPAN facility and surveys are closely aligned with CAASTRO goals, they are not presently receiving any funding from CAASTRO.

**OzDES**

Institutions: AAO, Australian National University, University of Queensland, The University of Sydney, University of Melbourne, Swinburne University of Technology, Monash University, Macquarie University, CSIRO, The Dark Energy Survey (members from over 30 institutions worldwide)

OzDES is a collaboration of over 20 Australian scientists, the vast majority of whom are CAASTRO members, using the AAT to gather thousands of spectroscopic redshifts to complement the photometric Dark Energy Survey. Host-galaxy redshifts for Type Ia supernovae will facilitate construction of the largest SN la Hubble Diagram to date, while repeat spectroscopy of high-redshift active galactic nuclei will attempt to use AGN reverberation mapping for standard candle cosmology beyond redshift 2.

**Cosmic neutral hydrogen absorption-line signals**

Institutions: The University of Sydney, European Southern Observatory (ESO)

CAASTRO members are carrying out a project to search for a statistical HI absorption-line signals in the reprocessed HIPASS data. HIPASS is a blind HI survey of the whole southern sky, carried out with the Parkes radio telescope from 1997-2002. Recent reprocessing of the data with modern algorithms has resulted in improved noise properties and band alignment, making it possible to search for weaker absorption-line signals than was previously possible. By stacking spectra towards bright radio continuum sources, where the sight-lines pass near to known optical galaxies in the HIPASS volume, we hope to be able to detect faint intervening absorption-line signals in the local universe (z < 0.04). The results of this project provide important information in the preparation for ASKAP-FLASH (the ‘First Large Absorption Survey in HI’), which will conduct a blind survey for HI absorption at redshifts 0.5 < z < 1.0 in order to study the evolution of neutral hydrogen with cosmic time.
the distance-redshift relation in the distant Universe
the acoustic peak in the WiggleZ survey data as a standard
on large scales, which is a test of the cosmological
taken with the Anglo-Australian Telescope to make
The collaboration has used the WiggleZ survey data
of large-scale structure. Data will also constrain the
galaxy contribution to reionisation from the full galaxy
of large-scale structure. It capitalises on the red sensitivity and large field of view
of CTIO’s DECam to detect the brightest and rarest
galaxies at z ≈ 6–7. Our results hint at the signature of large-scale structure. Data will also constrain the
galaxy contribution to reionisation from the full galaxy luminosity function. The observations will be executed with a cadence and depth to detect ‘super-luminous’ supernovae at z ≈ 6–7. This is a recently observed class 10–100× more luminous than typical. This class includes pair-instability supernovae, a rare, third type of supernova explosion for which only three events are known. The observations will greatly extend the current reach of supernova research, examining rates and properties in the Epoch of Reionisation.
The Hi signals from the Epoch of Reionisation.
the High Time Resolution Universe Survey for Pulsars and Fast Transients
Institutions: Observatorio Astronomico di Cagliari, CSIRO Astronomy and Space Science, University of Manchester, West Virginia University, Max Planck Institute for Radioastronomy, NASA Jet Propulsion Laboratory, Curtin University, Swinburne University of Technology
CAASTRO staff were involved in the High Time Resolution Universe survey collaboration in 2014. This survey searches the sky using the Parkes Multibeam Receiver and looks for phenomena with a time resolution of just 64 microseconds. 2014 has been a very successful year with the announcement of the discovery of fast radio bursts from what appear to be cosmological distances.

The 2MASS Tully-Fisher (2MTF) collaboration
Institutions: Australia Telescope National Facility (CSIRO), ICRAR/University of Western Australia, Monash University, National Astronomical Observatories (Chinese Academy of Sciences), Swinburne University, Texas A&M University, University of Cape Town, University of Portsmouth
This collaboration is working on measuring accurate distances to 3,000 spiral galaxies to investigate the effect of dark matter on the dynamics of the local Universe, and the validity of cold dark matter theory on large scales. New 21-cm observations have been made with the GBT and Parkes radio telescopes, and are being combined with photometry from the 2MASS infrared survey and data from other telescopes.

Epoch of Reionisation with the MWA
Institutions: University of Melbourne, Australian National University, University of Sydney, Curtin University, MIT, Harvard-Smithsonian Center for Astrophysics, University of Washington, Arizona State University, Raman Research Institute
CAASTRO staff are key members of the EdR collaboration within the MWA Project. This team is producing a data-reduction pipeline and a power-spectrum pipeline. Techniques are being tested with small datasets from the Murchison Widefield Array. These will ultimately be tested on the complete data set of more than 1,000 hrs. It is expected that the MWA will either detect or set limits on the detection of the Hi signals from the Epoch of Reionisation.

Large Synoptic Survey Telescope
Institutions: The Large Synoptic Survey Telescope (comprising more than 30 member organisations) and CAASTRO
CAASTRO and The Large Synoptic Survey Telescope (LSST) have entered into a Memorandum of Agreement on how CAASTRO can contribute to the operational support of LSST, which is planned to begin full scientific operations in the 2020 timeframe. In 2014 an LSST road show was conducted around Australia involving collaboration between CAASTRO, AAO, ANU, Swinburne and ICRAR.

DECam Deep Field
Institutions: Swinburne University of Technology, AAO, University of Melbourne, Space Telescope Science Institute, NOAO, CTIO
The DECam Epoch of Reionisation Project looks at the large-scale structure in the epoch of reionisation. It capitalises on the red sensitivity and large field of view of CTIO’s DECam to detect the brightest and rarest galaxies at z ≈ 6–7. Our results hint at the signature of large-scale structure. Data will also constrain the galaxy contribution to reionisation from the full galaxy luminosity function. The observations will be executed with a cadence and depth to detect ‘super-luminous’ supernovae at z ≈ 6–7. This is a recently observed class 10–100× more luminous than typical. This class includes pair-instability supernovae, a rare, third type of supernova explosion for which only three events are known. The observations will greatly extend the current reach of supernova research, examining rates and properties in the Epoch of Reionisation.

The 6dFGS Peculiar Velocity Field
Institutions: AAO, University of Melbourne, Swinburne University of Technology, University of Western Australia, University College London (United Kingdom), Monash University, University of Durham (United Kingdom), University of Western Kentucky (United States), Spitzer Science Center (California Institute of Technology, United States)
This collaboration has measured the distances to 10,000 galaxies belonging to the 6dF Galaxy Survey in order to measure the bulk flow of the local Universe and investigate the effect of gravity on the motions of galaxies. It has derived an accurate value for the density of ordinary matter in the local Universe.

WiggleZ
Institutions: Swinburne University of Technology, University of Toronto (Canada), AAO, The University of Sydney, University of Copenhagen (Denmark), University of Queensland, California Institute of Technology (United States), University of Waterloo (Canada), University of Chicago (United States), Institute of Astronomy and Astrophysics (Taiwan), CSIRO Astronomy and Space Science, Observatories of the Carnegie Institute of Washington (United States), Monash University, Swinburne University of Technology, University of British Columbia (Canada)
The collaboration has used the WiggleZ survey data taken with the Anglo-Australian Telescope to make new measurements of how the dumpy Universe on small scales transitions to a homogeneous Universe on large scales, which is a test of the cosmological model. It has also used the detection of the baryon acoustic peak in the WiggleZ survey data as a standard cosmological ruler to make new measurements of the distance-redshift relation in the distant Universe and produce new evidence in favour of cosmological constant dark energy.

GaLactic and Extragalactic All-sky MWA (GLEAM) survey
Institutions: Arizona State University, Australian National University, Australia Telescope National Facility (CSIRO), ICRAR/Curtin University, Harvard University, ICRAR/University of Western Australia, Massachusetts Institute of Technology, National Radio Astronomy Observatory, Raman Research Institute, Swinburne University, University of Melbourne, The University of Sydney, University of Tasmania, Victoria University of Wellington, University of Washington, University of Wisconsin.
The GaLactic and Extragalactic All-sky MWA (GLEAM) survey aims to image the entire sky south of declination +30 degrees at frequencies from 80 to 230 MHz. This survey will deliver the deepest-ever low-frequency view of the southern radio sky. Its aims include: the detection of giant radio galaxies and colliding clusters; the birth of radio galaxies; the structure of the Galactic magnetic field; the discovery of Galactic supernova remnants; and the measurement of cosmic-ray energy density. MWA observations over two years (starting in August 2013) have been allocated, with first results now starting to be published.

Collaborations – Outreach
MWA game design with Quantum Victoria
The CAASTRO Education and Outreach team has partnered with the software developers at Melbourne’s science learning centre ‘Quantum Victoria’, led by CAASTRO Advisory Board member Soula Bennett, to create a game based on the Murchison Widefield Array (MWA). CAASTRO provides scientific input into the game design and will be responsible for educational resources that enable science teachers to prepare their students, predominantly Year 9 and above, for their visit to Quantum Victoria and assess their experience afterwards.

Astronomy Weekend and ‘Astronomer in Residence’ at Uluru
In collaboration with Voyages Indigenous Tourism Australia, CAASTRO has ‘Astronomers in Residence’ at Uluru for most of the year and in 2014 we held the inaugural Uluru Astronomy Weekend as part of National Science week. CAASTRO team members gave presentations about the Universe and offered insights into current avenues of astrophysical research.

Animation library from Swinburne Astronomy Productions
In 2014, CAASTRO continued its relationship with Swinburne Astronomy Productions to develop a large media library of high quality 2D and 3D animation material for use in CAASTRO presentations and outreach activities. All three CAASTRO themes will be well represented and able to draw on this valuable resource for explaining fundamental physical concepts and specific topics of CAASTRO research.

Production of a planetarium show
With the view that CAASTRO all-sky data is most naturally presented on a domed screen, CAASTRO has entered into a longer-term collaboration with Museum Victoria for the production of a planetarium show. Aiming at a premiere in 2016, CAASTRO and the team at Melbourne Planetarium are working towards showcasing CAASTRO research results and real datasets for shows in several Australian and overseas locations.
**GRANTS WON BY CAASTRO MEMBERS IN 2014**

**ARC Discovery Project**
- Project Title: Mapping quasars: micro-imaging experiments
  - Project Code: DP150101727
  - Funding: $357,000 over 3 years (2015, 2016, 2017)
  - Chief Investigator: Rachel Webster

**ARC LIEF**
- Project Title: Hector – a revolutionary spectrograph for understanding how galaxies evolve
  - Project Code: LE150100070
  - Funding: $270,000
  - Chief Investigator: Jeremy Mould
  - CAASTRO Investigator: Anne Green

**ARC LIEF**
- Project Title: An Ultra-wideband Radio Receiver for the Parkes Radio Telescope
  - Project Code: LE150100155
  - Funding: $370,000
  - Chief Investigator: Matthew Bailes
  - Other CAASTRO Investigators: Bryan Gaensler, Stuart Wyithe, Ramesh Bhat, Willem van Straten, and Michael Kramer

**ARC LIEF**
- Project Title: The Australian European Southern Observatory Positioner (AESOP)
  - Project Code: LE150100055
  - Funding: $560,000
  - Chief Investigator: Simon Driver
  - CAASTRO Investigators: Chris Power, Martin Meyer, and Warrick Couch

**ARC LIEF**
- Project Title: Exploiting SkyMapper for Galactic Astrophysics
  - Project Code: DP150103294
  - Funding: $384,700 over 3 years (2015, 2016, 2017)
  - Chief Investigator: Emma Ryan-Weber
  - CAASTRO Investigator: Michael Kramer

**ARC LIEF**
- Project Title: The Cherenkov Telescope Array
  - Project Code: LE150100070
  - Funding: $270,000
  - Chief Investigator: Gavin Rowell
  - CAASTRO Investigator: Anne Green

**ARC Laureate Fellowship**
- Project Title: The origin of dwarf elliptical galaxies: little giants or regular irregulars?
  - Project Code: FL140100278
  - Funding: $363,092 over 3 years
  - Chief Investigator: Nicholas Scott

**In-Kind Contributions**
- University of Sydney: $1,043,578
- University of Western Australia: $169,865
- University of Melbourne: $304,602
- Swinburne University of Technology: $524,226
- Australian National University: $755,215
- Curtin University of Technology: $271,474
- CSIRO: $3,370,146
- Anglo-Australian Observatory: $1,014,604
- Max Planck Institute for Radio Astronomy: $146,695
- California Institute of Technology: $134,673
- The University of Oxford: $61,170
- Durham University: $202,108
- Max Planck Institute for Astrophysics: $76,137
- The University of Arizona: $160,000
- The University of Toronto: $41,300
- Laboratoire de Physique Nucléaire et de Hautes Energies: $160,088
- National Computational Infrastructure: $1,000,000
- Raman Research Institute: $200,000
- University of Queensland: $92,413
- Voyages Indigenous Tourism: $45,000
- Total In-Kind Contributions: $9,763,294
CAASTRO EXECUTIVE

1. Elaine Sadler (Director)
2. Lister Staveley-Smith (Deputy Director)
3. Kate Gunn (Chief Operating Officer)
4. Matthew Bailes (Dynamic theme leader)
5. Stuart Wyithe (Evolving theme leader)
6. Steven Tingay (Education and Outreach leader)
7. Tamara Davis (Dark theme leader)

CAASTRO PEOPLE

Partner Investigators
17. Lindsay Botten
18. Brian Boyle
19. Warrick Couch
20. Roger Davies
21. Xiaohui Fan
22. Carlos Frenk
23. Andrew Hopkins
24. Simon Johnston
25. Michael Kramer
26. Shri Kulkarni
27. Ray Norris
28. Reynald Pain
29. Ue-Li Pen
30. Mara Salvato
31. Ravi Subrahmanyan

Chief Investigators
8. Chris Blake
9. Frank Briggs
10. Matthew Colless
11. Scott Croom
12. Bryan Gaensler
13. Jeremy Mould
14. Tara Murphy
15. Brian Schmidt

16. Rachel Webster

Associate Investigators
32. Ramesh Bhat
33. Joss Bland-Hawthorn
34. Jamie Bolton
35. Chris Lidman
36. Jean-Pierre Macquart
37. Martin Meyer
38. Stephen Ord
39. David Parkinson
40. Chris Power
41. Ashley Ruitter
42. Emma Ryan-Weber
43. Richard Scalzo
44. Ivo Selenzaahl
45. Robert Sharp
46. Stuart Sim
47. Randall Wayth
48. Christian Wolf
49. Ixandra Achitouv
50. Julia Bryant
51. Michael Childress
52. Chris Flynn
53. Lisa Fogarty
54. Anna Kapinska
55. Eyal Kazin
56. Evan Keane
57. Jun Koda
58. David Lagattuta
59. Emil Lenc
60. Edward Macauley
61. Felipe Marin
62. Ben McKinley
63. Vanessa Moss
64. André Offringa
65. Se-Heon Oh
66. Attila Popping
67. Pietro Procopio
68. Vikram Ravil
69. Jongwah Rhee
70. Nicholas Scott  
71. Marcin Sokolowski  
72. Christopher Springob  
73. Dan Taranu  
74. Edoardo Tescari  
75. Steven Tremblay  
76. Laura Wolz  
77. Fang Yuan

**CAASTRO Professional Staff**

78. Kim Dorrell  
    (Executive Officer, U. Melbourne)  
79. Angela Dunleavy  
    (Administrative Coordinator, Curtin U)  
80. Wiebke Ebeling  
    (Education & Outreach Coordinator)  
81. Debra Gooley  
    (Finance Officer)  
82. Sue Lester  
    (Administration Officer, Swinburne)  
83. Clare Peter  
    (Administrative Officer, UWA)  
84. Helen Sim  
    (Public Relations Officer)  
85. Denise Sturgess  
    (Administration Officer, ANU)  
86. Michelle Sullivan  
    (Executive Assistant to Director)  
87. Kylie Williams  
    (Events & Communications)

**CAASTRO Affiliates**

88. Candy Wu  
    (Administration Officer, ANU)  

89. James Allen  
90. James Allison  
91. Keith Bannister  
92. Ewan Barr  
93. Holger Baumgardt  
94. Martin Bell  
95. Davide Burton  
96. Mike Dalley  
97. Jacinta den Besten  
98. Duncan Campbell-Wilson  
99. Weiguang Cui  
100. Stephen Curran  
101. Jason Dossett  
102. Michael Drinkwater  
103. Alan Duffy  
104. Jamie Farnes  
105. Sean Farrell
106. Ilana Feain
107. Karl Glazebrook
108. Anne Green
109. Paul Hancock
110. Tao Hong
111. Andrew Jameson
112. Hansik Kim
113. Iraklis Konstantopoulos
114. Katherine Mack
115. Greg Madsen
116. Daniel Mitchell
117. Richard Newton
118. Shane O’Sullivan
119. Danail Obreschikow
120. Bart Pindor
121. Signe Riemer-Serensen
122. Antonia Rowlinson
123. Edward Taylor
124. Cathryn Trott
125. Willem van Straten

**CAASTRO Students**
126. Caitlin Adams
127. Eromanga Ademann
128. Shivani Bhandari
129. Jessica Bloom
130. Loren Bruns Jr.
131. Manisha Pranati Caleb
132. Joe Callingham
133. Alexandru Codoreanu
134. Catherine De Burgh-Day
135. Angela Garcia
136. Marcin Glowacki
137. Samuel Hinton
138. Fabian Janikowski
139. Andrew Johnson
140. Antonios Katsianis
141. Anthea King
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