CAASTRO

ARC CENTRE OF EXCELLENCE
FOR ALL-SKY ASTROPHYSICS

THREE

ANNUAL REPORT 2013

CONTENTS

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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INTRODUCTION FROM THE CHAIR

DR ALAN FINKEL AM FTSE
CHAIR, CAASTRO ADVISORY BOARD

This is now my third introduction to the CAASTRO annual report, and it is hugely satisfying to once again be in the position of having a picture of progress on all fronts to comment on. The simplest illustration of this is CAASTRO's expanding headcount, with the University of Queensland joining the program in 2013 and recruitment underway for new researchers to join in 2014. With so much happening, with preparatory work for the SKA in full swing and progress on other CAASTRO projects, it is truly an exciting time for astronomy in the world generally, and in Australia in particular. It is gratifying to know that, under Bryan Gaensler's judicious management, CAASTRO is gearing to extract the most scientific value it can from the increasingly vast and rich deluge of data that is coming its way.

This is not at all to say that CAASTRO spent 2013 only preparing for the future. Ongoing research saw a very productive year for publications, topping the already highly respectable number of papers published in 2012. This record reflects how CAASTRO continues to push out the boundaries of our knowledge with exciting new finds, the discovery of fast extragalactic radio bursts providing perhaps the most tantalising example from this year. Education and public outreach programs also continued strongly, demonstrating CAASTRO's understanding of itself as an institutional citizen not simply dedicated to research, but actively engaged with the community.

I am sure that all members of CAASTRO were further encouraged in their endeavours in 2013 by the number of awards bestowed upon CAASTRO investigators and other program staff. While such awards primarily recognise the excellence of the individuals concerned, it is not unreasonable to claim some of that recognition as reflected on colleagues and the programs in which the awardees operate. As Chairman of the CAASTRO advisory board I am proud to be associated with an organisation that produces excellence. My congratulations go to all award winners in 2013, but in particular to Prof. Brian Schmidt, who was made a Companion of the Order of Australia, and Dr Brian Boyle, who received a Public Service Medal, in the 2013 honours list.

Lastly, I would like to mention collaboration, which of course is a core goal of CAASTRO. A good example from 2013 was use of the Giant Metre-wave Radio Telescope (GMRT) in India to gather data that was then processed at Swinburne University in Melbourne. But my interest in collaboration is personal as well, as this year I attended the 10th Australia-China Symposium run by the Chinese Academy of Sciences, the Australian Academy of Science, and the Australian Academy of Technological Sciences and Engineering. The theme was astronomy and astrophysics, and provided an excellent opportunity to advance existing collaborations and pave the way for new ones. China's centuries-long legacy in astronomy is backed up today with significant resources in telescope infrastructure and research capacity. It was exciting for me to be present at an interface with so much potential; how much more exciting it must have been for the astronomers present, including CAASTRO's Dr Brian Boyle who co-convened the event.

Again, for this year, I would like to thank the CAASTRO advisory board for their work, and the CAASTRO executive team, researchers, staff and students for all contributing to the success of this exciting and worthy enterprise.

VISION & MISSION STATEMENT

ASKAP
Credit: Emil Lenc

The CAASTRO Vision

CAASTRO will be an international leader in wide-field astronomy, positioning Australia to address fundamental unsolved questions about the Universe with the dramatic capabilities of next-generation telescopes and advanced instrumentation.

The CAASTRO Mission

CAASTRO is carrying out key science with 21st century telescopes. Our underlying goals are:

DISCOVER To make ground-making advances in our understanding of the Universe, thereby cementing Australia's reputation as a world leader in astrophysical research;

INNOVATE To develop innovative new ways of surveying the entire sky, of processing enormous volumes of astronomical measurements, and of visualising complex data sets, so as to build unique expertise in wide-field radio and optical astronomy;

PERFORM To make high-impact discoveries using Square Kilometre Array pathfinder telescopes, thus positioning Australia to lead the science programs planned for the SKA;

EDUCATE To provide compelling new opportunities for students and early-career researchers and exciting stories to inform the public; and

UNITE To bring the top astronomers from Australia and around the world together into a focused collaborative environment.

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 data sets 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 will 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 then evolved?
- 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.

DIRECTOR'S REPORT

PROF BRYAN GAENSLER
CAASTRO DIRECTOR

The Annual Report you're about to read represents a year packed with highlights and success stories. 2013 was the year in which our science, training, education and outreach programs all hit full speed. As a result, we have been able to produce a torrent of exciting new results and ideas.

Within CAASTRO's Evolving Universe theme, we have now commenced our flagship surveys with the Murchison Widefield Array (MWA) and the Sydney-AAO Multi-object Integral field spectrograph (SAMI). The MWA and SAMI are both now delivering huge data sets aimed at transforming our view of the Universe. Throughout 2013 we published many scientific results that demonstrate the spectacular capabilities of the MWA, on topics ranging from tracking of space debris to particle acceleration in giant radio galaxies. Meanwhile, the SAMI Galaxy Survey was awarded long-term large program status on the Anglo-Australian Telescope (AAT), guaranteeing our team 150 nights of time over the next three years to make 3D maps of more than 3000 galaxies. Elsewhere within the Evolving Universe research theme, CAASTRO student Jongwhan Rhee has stacked the 21cm hydrogen emission from over 150 galaxies to measure the evolution of the gas content of the Universe over the last 2.4 billion years, while postdoc Edoardo Tescari has used super-computer simulations of the high-redshift Universe to show the ways in which star formation at these early times depends on winds and feedback.

It was a bonanza year for our Dynamic Universe research program. Most notable was the paper published in *Science* in July, reporting the discovery of four fast rapid radio bursts of extragalactic origin. These bursts, which appear to be the same phenomenon as the famous solo "Lorimer burst" of 2001, are potentially an entirely new class of astronomical objects. The hope is that fast radio bursts can now provide unique insights into extreme physics, and can also act as a superb probe of the intervening intergalactic medium. Their discovery has prompted a flurry of follow-up activity across CAASTRO, ranging from theoretical predictions of intergalactic scattering to new efforts to detect and localise these bursts using the MWA and Molonglo. CAASTRO also produced a range of other innovative new insights into variable and transient behaviour across the electromagnetic spectrum: Greg Madsen studied the changes in brightness of 44 million stars over 60 years by comparing photographic plates to modern digital sky surveys, Paul Hancock used visibility stacking to show that there must be two distinct types of radio afterglows for gamma-ray bursts, while Kitty Lo submitted a superb PhD thesis on automatic classification of variable and transient sources at radio, X-ray and optical wavelengths.

In the Dark Universe theme, data began to flow from our ambitious SkyMapper survey for nearby Type Ia supernovae. Within days of the first observations, SkyMapper discovered its first supernova, and amazingly it was a Type Ia! The quality of the data, combined with the powerful follow-up capabilities of WiFeS, bodes extremely well for success in this area. In other activities within our Dark theme, CAASTRO postdoc David Lagattuta derived a precision infrared Tully-Fisher relation from an enormous all-sky galaxy catalogue, while a large CAASTRO team led by Jun Koda has performed some comprehensive simulations demonstrating the ways in which our forthcoming peculiar velocity surveys will be able to probe gravity and Dark Energy. CAASTRO made some major strategic additions to our research program in 2013, aimed at boosting our research capacity within the Dark Universe theme. First, we welcomed The University of Queensland as a seventh node to CAASTRO, with Tamara Davis as a new Chief Investigator and node leader. Our new CAASTRO members from Queensland bring some impressive theoretical expertise to our programs, particularly in the areas of Dark Energy, cosmology and modified gravity. In addition, we made the decision to add a new CAASTRO project, in which we will provide postdoctoral support to the OzDES survey. OzDES is a large project to obtain redshifts to supernova host galaxies using the AAT. The supernova discoveries themselves are coming from the Dark Energy Survey (DES), while OzDES will then use the unique wide-field spectroscopic capabilities of the AAT to obtain the redshifts needed to perform precision cosmology. We're excited to now be part of this project.

While there were many highlights within our specific programs for each theme, the exciting thing is that the boundaries between each theme are now becoming blurry. The propagation effects seen in fast radio bursts may prove key to understanding how large-scale structure has formed and evolved over the Universe's history; the polarimetric calibration techniques which we've been developing for reionisation studies with the MWA are now being used to look for polarised transients; and our growing set of activities in stacking, intensity mapping, peculiar velocity measurements and direct shear mapping are providing simultaneous information on the properties of individual galaxies and on the underlying Dark Matter and Dark Energy.

CAASTRO continues to grow. We now have over 140 members, including 25 postdocs and 40 students. As our Centre continues to develop and evolve, we've made a few important structural changes. Brian Schmidt has taken on a new role within CAASTRO as the chair of our committee on gender and diversity, and will represent this committee on the CAASTRO executive. I look forward to working with Brian on this important issue, and thank him for his excellent leadership of the Dark Universe theme over the last several years. I have appointed Tamara Davis as the new leader of the Dark Universe (December 2013), and correspondingly welcome her to the CAASTRO executive team. We also welcome three new theme scientists, who will assist the theme leaders in managing and overseeing the research activities and strategic plan within each theme: Lisa Fogarty (Evolving Universe), André Offringa (Dynamic Universe) and Michael Childress (Dark Universe). I offer huge thanks to our three outgoing theme scientists, Emil Lenc (Evolving), Steve Tremblay (Dynamic) and Chris Springob (Dark), who all took on these roles with enthusiasm and professionalism.

I was thrilled at the stream of impressive awards that our members received this past year. Most notably, CAASTRO investigators Brian Schmidt and Brian Boyle both were recognised with Australia Day honours. Brian Schmidt received a Companion of the Order of Australia (AC) "for eminent service as a global science leader", while Brian Boyle was awarded a Public Service Medal (PSM) "for leadership of the Australian team bidding to host the Square Kilometre Array". These are some of the highest honours that any Australian can receive, and were both thoroughly deserved. In addition, I congratulate Rachel Webster on giving the Ellery Lectureship to the Astronomical Society of Australia, and Chris Blake on receiving the Pawsey Medal from the Australian Academy of Science.

CAASTRO ran a diverse collection of workshops and conferences throughout 2013. Our marquee event of the year was our first major conference. "Reionisation in the Red Centre", held at Uluru in July 2013. This meeting had excellent international attendance and featured several rapidly moving topics in the high-redshift Universe. I also highlight our joint workshop on astroparticle physics with the ARC Centre of Excellence for Particle Physics at the Terascale (Melbourne, February 2013), our meeting on "Synthetic Universes for Future Surveys" (Perth, March 2013) and the conference "Ephemeral Universes with Widefield Arrays" (Perth, November 2013). We ended the year with another excellent CAASTRO Annual Retreat, this time held in Torquay on Victoria's surf coast. The notable feature of this meeting was the uniformly excellent standard of the talks and posters from postdocs and students; the tightly contested golf-cart rally also deserves special mention.

Our education and outreach programs continue to hit new heights, thanks to the innovative and strategic leadership of Wiebke Ebeling and Steven Tingay. CAASTRO in the Classroom continues to grow, now under the guidance of Jamie Farnes and Shane O'Sullivan – we were excited by the chance to bring CAASTRO into Chinese classrooms in 2013, and will be looking to develop this possibility further in the future. We brought several high-profile science communicators to Australia for National Science Week, featured in the children's television series "Enquiring Minds", and ran activities such as astronomy festivals, astrophotography competitions and school telescope programs throughout the year. We continue to be a leader in science social media, having now accumulated 35,000 views on our YouTube channel, and more than 18,000 likes on Facebook. We are currently developing new outreach collaborations with Voyagers Tourism, Melbourne Planetarium and Swinburne Astronomy Productions, which I hope to be able to tell you about in 2014.

In conclusion, I offer my deep thanks for the continued and unflagging support of the entire CAASTRO community. Our universities and partner organisations continue to be fantastically enthusiastic and flexible – we deeply appreciate their generous contributions of brains and dollars. Key stakeholders such as the Australian Research Council, the NSW government, CSIRO, NCI, ICRAR and the AAO all have also been engaged, responsible and proactive in helping us meet our goals. CAASTRO has also greatly benefited this year from some extremely sound and strategic advice from our Advisory Board: I thank Alan Finkel and the rest of the Board for their insightful recommendations and insights that have played a pivotal role in our strategies and planning. It is a delight to work with CAASTRO's superb administrative team – all across CAASTRO, things run smoothly and efficiently thanks to their dedication and professionalism. Our Chief Operations Officer Kate Gunn continues to push CAASTRO to new heights with her vision and business acumen, while one of CAASTRO's core strengths is the experience and insight of the Deputy Director, Lister Staveley-Smith and the rest of the hard-working CAASTRO executive team.

You will be excited and inspired by the many discoveries, stories and activities you will find in the following pages.

RESEARCH PROGRAMS

Pietro Procopio (UMelb/CAASTRO), Daniel Mitchell (UMelb/CAASTRO) and Gianni Bernardi (CfA Harvard University) at the MWA Busy Week in Melbourne.
Credit: Emil Lenc

THE EVOLVING UNIVERSE

Theme Leader: Professor Stuart Wyithe | The University of Melbourne

Theme Scientist: Dr Emil Lenc | The University of Sydney

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, for which CAASTRO's Evolving Universe theme is focused on providing key new insights.

CAASTRO researchers are searching for the faint radio signal from the "Epoch of Reionisation", the period when stars, galaxies and quasars ionised the entire Universe. We know that a million years after the Big Bang, the Universe was smooth, simple, and was filled with neutral hydrogen. In contrast, 13.8 billion years later, the Universe today is complex and inhomogeneous, and almost all the hydrogen is ionised. There had to have been an intervening reionisation process, but this has not yet been observed. The Epoch of Reionisation is the last major phase of the Universe's evolution still to be studied or understood.

The CAASTRO team is also performing new surveys to measure the stellar and gaseous composition of many tens of thousands of galaxies, spread all over the sky and covering a huge range of ages and distances. These measurements will not only provide a view of stars and gas in individual galaxies in unprecedented detail, but will span a cosmologically representative volume, thus opening up a completely new parameter space for understanding galaxy evolution. We will use these data to address the role of gas, stars and outflows in galaxy formation and evolution, to track the evolution of star formation over cosmic time, and to study normal galaxies over eight billion years of the Universe's history.

A New Wide-Field View Of Centaurus A

Centaurus A is one of the most well-known and well-studied radio galaxies. At a distance of 12 million light-years, it's also the closest. That proximity, combined with the galaxy's large intrinsic size, means the radio source extends some 4° x 8° across the sky. As a result, past radio telescopes have had to make many pointings to image the entire galaxy, making studies of the radio source as a whole highly problematic.

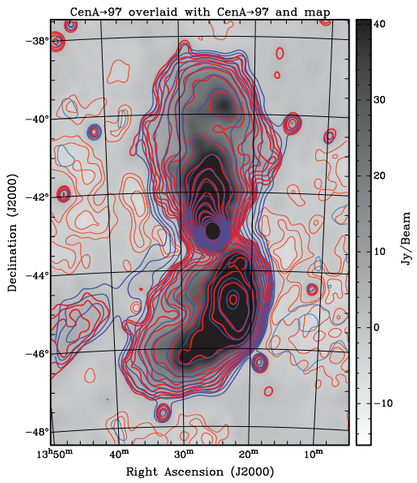
Fortunately, the Murchison Widefield Array (MWA) in Western Australia, designed with a very wide field of view to detect the faint redshifted 21-cm signal from the Epoch of Reionisation, can also be used to study extended objects such as Centaurus A.

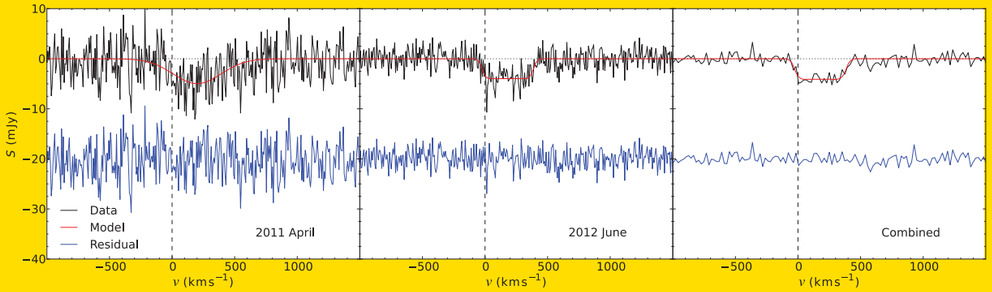
CAASTRO PhD student Ben McKinley led a large team that observed Centaurus A at 118 MHz with the MWA 32-tile prototype in April/May 2011.

Centaurus A has prominent radio lobes with distinctive and complex morphologies. There is a pair of "inner lobes", a northern "middle lobe", and the giant "outer lobes". One theory to explain this nested structure is that Centaurus A has had a number of outbursts of nuclear activity, with the inner lobes due to the most recent outburst. A problem with this theory has been the lack of evidence for a southern counterpart to the northern middle lobe.

One of the main findings made by McKinley et al. is that their 118 MHz map and associated spectral-tomography results provide evidence for structure in the southern lobe consistent with the missing "southern middle lobe". Future observations with the full 128-tile Murchison Widefield Array, with its higher angular resolution and increased sensitivity, will shed further light on whether this is in fact the missing structure needed to explain the outflow history of Centaurus A. The team's paper *"The giant lobes of Centaurus A observed at 118 MHz with the Murchison Widefield Array"* was published in December 2013 in *Monthly Notices of the Royal Astronomical Society*.

An image of Centaurus A at 118 MHz, obtained with the Murchison Widefield Array. The MWA data are shown in greyscale and red contour lines, overlaid with 1.4 GHz contours from Parkes in blue. There are a few areas, in particular the northern part of the southern giant lobe, where there appears to be additional structure visible at 118 MHz that is not present at 1.4 GHz. ***CREDIT: McKinley et al***





The results of fitting HI absorption to spectral data taken in April 2011 and June 2012 with the Australia Telescope Compact Array. The black line represents the data after subtracting the best-fitting (i.e., maximum likelihood) continuum component, and the red line represents the best-fitting spectral line model. The blue line is the resulting residual.
CREDIT: Allison et al.

Cold Hydrogen in Distant Galaxies

Absorption lines of cool atomic neutral hydrogen are an important tool for studying the evolution of galaxies, as the distributions and velocities of these lines give unique insights into the structure of galaxies.

CAASTRO researchers James Allison, Stephen Curran, Elaine Sadler and PhD student Sarah Reeves are carrying out pilot studies for an ambitious all-sky survey of HI absorption to be pursued with the Australian Square Kilometre Array Pathfinder (ASKAP). As part of this pilot work, Allison et al. performed a detailed study of a candidate HI absorption line system seen toward the early-type galaxy PMN J2054-4242, using new data obtained with the Australia Telescope Compact Array Broadband Backend.

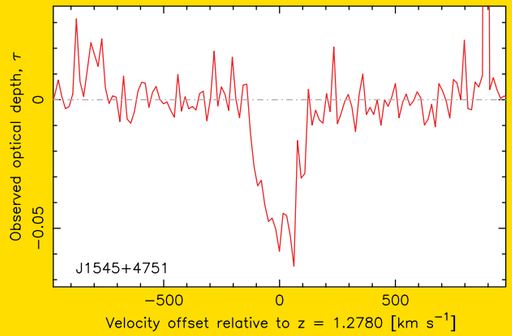
The team first needed to confirm whether they had indeed detected HI absorption, given the weakness of the signal; this will be a key ongoing issue for the observations planned for ASKAP. They estimated the probability of a spectral line model versus a continuum-only model, with no prior assumptions about the probability of detection of a spectral line. Their analysis showed that a detection of HI had been made at a significantly significant level. The team then considered the physical nature of the strong broadening seen in the absorption line, possibly pointing to it being cold gas rotating with high velocity or infalling at an accelerated rate along the line of sight. They plan to follow up these observations at higher resolution and at multiple wavelengths. Not only was this one of the broadest and weakest 21-cm absorption lines ever found, it importantly was a successful test of their spectral line finding method to be utilised for ASKAP.

Their paper "*Broad, weak 21 cm absorption in an early type galaxy: spectral line finding and parametrization for future surveys*", was published in March 2013 in *Monthly Notices of the Royal Astronomical Society*.

Curran and Sadler have been performing other HI absorption work, in collaboration with astronomers from CSIRO, The University of New South Wales and the Indian Institute of Science Education and Research. Their paper "*w*", also published in March 2013 in *Monthly Notices of the Royal Astronomical Society*, describes their search for cool neutral gas at galaxies with a redshift of around z = 1.

There have been relatively few detections of neutral atomic hydrogen in galaxies at a redshift of z = 1 or greater. The reason that CAASTRO researcher Stephen Curran had previously proposed for this is that the high-redshift galaxies selected for surveys are bright at ultraviolet wavelengths. That ultraviolet luminosity, however, is likely to have ionised all the neutral gas in the host galaxy, preventing any detection of an HI signal. To counter this effect, the team selected ten galaxies whose ultraviolet luminosities were below the critical level that should produce galaxy-wide ionisation. Each of these galaxies was observed with the Giant Metrewave Radio Telescope in India over the period 22-24 January 2012.

For one of the galaxies, SDSS J154508.52+475154.6 at a redshift of z = 1.278, there was a clear detection of redshifted HI 21-cm absorption. This is the third highest redshift detection of HI absorption. After analysing the results of the searches for the other nine galaxies, the team estimated that the real detection rate for HI absorption in galaxies at redshift of z ~ 1 is around 30%. This confirms that future next generation radio telescopes such as the Square Kilometre Array will be very successful at studying cold gas at high redshifts.



HI 21-cm absorption in the galaxy SDSS J154508.52+475154.6.
CREDIT: Curran et al.

PERFORM

Tracking the Evolution of Gas in Galaxies

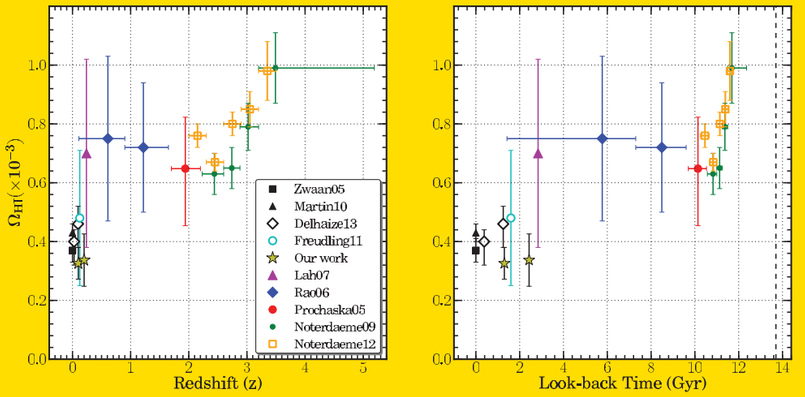
Over the last 8 billion years (i.e., from a redshift z = 1 to the present), the rate of star formation in the Universe has fallen by an order of a magnitude. Star formation is driven by the amount of neutral hydrogen in galaxies, but it remains unclear how the amount of neutral hydrogen gas available for making stars has changed during this time. Previous studies have shown that the amount of neutral hydrogen in galaxies is seemingly insufficient to account for observed stellar populations and ongoing star formation. Various ideas such as gas accretion from the intergalactic medium or infalling gas from mergers have been suggested to account for this deficit.

To provide a new understanding of how the neutral hydrogen gas content of galaxies has evolved over time, CAASTRO PhD student Jonghwan Rhee, along with Frank Briggs, Philip Lah and others, has obtained HI observations with the Westerbork Synthesis Radio Telescope of 155 galaxies. These galaxies had all had their redshifts measured as part of the second Canadian Network for Observational Cosmology (CNOC2) Field Galaxy Redshifts Survey.

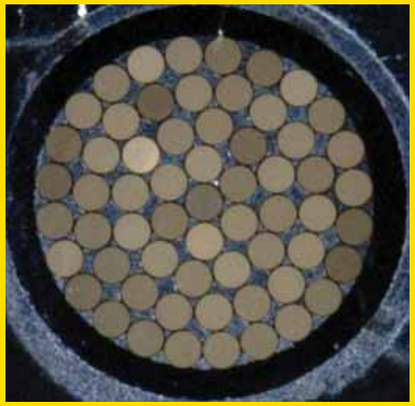
Rhee et al. found that only 11 of the 155 galaxies had significantly high signal-to-noise radio detections, so the team used a spectral signal stacking technique to measure the HI content of all 155 galaxies. They found that at a redshift z ~0.2, most of the neutral hydrogen gas was found in intermediate and late-type galaxies, while early-type galaxies contained less than 2% of the Universe's neutral hydrogen gas. In contrast, at z ~0.1, early-type galaxies appeared to contribute about 22% of the neutral gas budget.

From their HI measurements, Rhee et al. were able to calculate the cosmic HI gas density as a function of redshift. From their data, they found that for the 59 galaxies at z ~0.1, the neutral hydrogen density was $(0.33 \pm 0.05) \times 10^{-3}$ (relative to the present critical density of the Universe), and for the 96 galaxies at z ~ 0.2, the density was $(0.34 \pm 0.09) \times 10^{-3}$. Combined with measurements in the local Universe (z = 0), this is consistent with there being no evolution in the density of neutral hydrogen gas over the last 2.4 billion years. Comparing their results to other studies at other redshifts, the team noted that neutral hydrogen gas densities for the redshift range z = 0.2 to z = 1.2 are considerably higher than at other points in the Universe's history, albeit with greater uncertainties.

The team's paper "*Neutral atomic hydrogen (HI) gas evolution in field galaxies at z ~ 0.1 and 0.2*" was published in November 2013 in *Monthly Notices of the Royal Astronomical Society*. They are now investigating the HI content of the Universe at higher redshifts, in the range z = 0.32 to 0.36.



The evolution of the cosmic neutral hydrogen gas density over time. Rhee et al.'s observations are represented by the gold stars and show no change between z = 0 and z = 0.2. This is in stark contrast to the substantial evolution seen to be occurring at earlier times.
CREDIT: Rhee et al



One of the 61-core lightly-fused hexabundles. The cores are 105 microns in diameter and 115 microns with cladding. The interstitial holes are filled with a soft, low-refractive-index glue.
CREDIT: Bryant et al.

Hexabundles for Multi-Object Spectroscopy

Over the past two decades, astronomers have performed multi-object spectroscopy by using many single fibres each pointed at a different galaxy. Through this approach, we have amassed large galaxy samples from which global properties and evolutionary trends have been deduced. However, the data can be misleading when the same-sized fibres are used to obtain spectra of all galaxies irrespective of their size, distance or morphology.

Spatially-resolved spectroscopy is the new frontier, in which integral field units (IFUs) give a spectrum at each position across a galaxy. The data therefore can trace the location and dynamics of stars, gas and dust in each galaxy, leading to significant advances in our understanding of galaxies' morphologies and evolution. While IFUs have been very effective in studies of individual galaxies, up until recently the number of objects that could be accumulated through IFU observations has been limited.

Motivated by the need for spatially-resolved spectroscopy on large samples of galaxies, researchers at The University of Sydney and AAO have developed a device called a "hexabundle". Each hexabundle gives spatially resolved spectra just as for an IFU; however, many hexabundles can be placed across a field simultaneously just like for traditional fibre-based multi-object spectroscopy, resulting in simultaneous spatially-resolved spectra of many galaxies. Hexabundles are now in operation in the SAMI instrument installed at the 3.9-metre Anglo-Australian Telescope, and are currently being used to undertake a survey of 3,400 galaxies. This is the largest spatially-resolved galaxy survey ever undertaken.

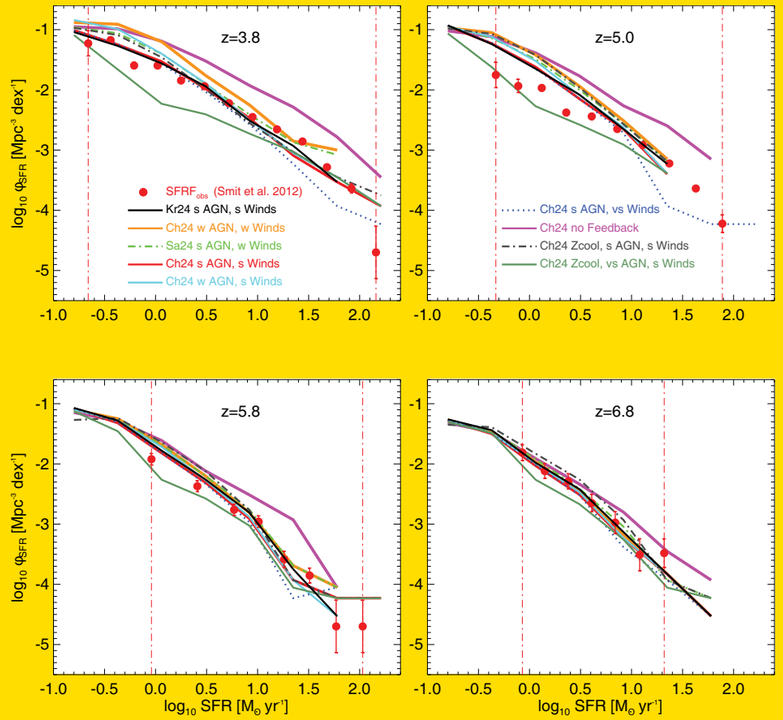
Hexabundles are formed from optical fibres. However, optical fibres can suffer from focal ratio degradation, in which the light entering the fibre has a set cone angle, but comes out of the fibre with a larger cone angle. Valuable light will be lost if this cone angle exceeds the acceptance cone of the spectrograph. For astronomical use where light levels are very low, it is therefore essential that focal ratio degradation in optical fibres be minimised.

CAASTRO researchers Julia Bryant, Joss Bland-Hawthorn, Lisa Fogarty and Scott Croom, along with Jon Lawrence (AAO), have characterised the focal ratio degradation and throughput of several hexabundle devices. Their results are detailed in their paper *"Focal ratio degradation in lightly-fused hexabundles"*, accepted for publication in *Monthly Notices of the Royal Astronomical Society* in November 2013.

Bryant and her team tested hexabundle devices over the range of beam speeds (f-ratios) used in astronomy. They show that the focal ratio degradation improves with the lower f-ratios typically used for fibre instruments, as expected from single fibre results. However, they then demonstrate that their new method of forming hexabundles does not induce any more focal ratio degradation than that of the original fibre that comprises the hexabundles - a significant improvement on earlier processes. These results now prove the viability of these devices in astronomical instruments.

A unique feature of this design is that the cladding encasing each fibre core is thinned down by etching before the fibre is fused into the device. This increases the throughput due to a larger fill-fraction (i.e., more light is collected in a core compared to that lost in the cladding). However, thinner cladding can affect the guiding of light through the fibre. Bryant et al. present a detailed analysis of the impact of the optical fibre cladding on the light, through scattering between fibre cores in the hexabundle. They tested cladding thicknesses from 1 to 8 microns, and showed that by thinning the cladding from 10 microns down to only 2 microns thick, there is negligible negative impact on the guiding of the light. Furthermore, they quantify the losses from focal ratio degradation, which can be used to set physical limits on future instruments designed to feed hexabundles.

The success of hexabundles on wide-field telescopes has now prompted the development of new types of hexabundles with regular hexagonal fibre packing and square cores. The team concludes that hexabundle technology will come to dominate future large galaxy surveys.



A plot of the simulated star formation rate functions at $z \sim 4 - 7$, compared to recent observational results (Smit et al. 2012).
CREDIT: Tescari et al.

Simulating Star Formation in Very High Redshift Galaxies

With the advent of powerful deep and wide surveys now and in the near future, more and more distant galaxies and quasars are being discovered and studied. Understanding how galaxies and quasars evolve at high redshift remains an area in which much work still needs to be done. Key to the evolution of galaxies is the evolution of the star formation rate itself.

CAASTRO researchers Edoardo Tescari, Antonios Katsianis and Stuart Wyithe, along with colleagues from University Observatory Munich, Trieste Astronomical Observatory and the University of Trieste, have created a new set of cosmological simulations under the project name ANGUS (AustraliaN GADGET-3 early Universe Simulations). ANGUS is based on an improved version of the parallel TreePM-Smoothed Particle Hydronamics (SPH) code GADGET-3. The team ran their simulations at the National Computational Infrastructure National Facility at the Australian National University, with post-processing on the Edward High Performance Computing cluster at the University of Melbourne. They compared their results with recently published analyses of high-redshift observations.

The software code models stars with masses in the range 0.1 to 100 solar masses; the code follows the evolution of metals released from type Ia and type II supernovae, along with the effects of low and intermediate mass stars. Only stars lighter than 40 solar masses are allowed to explode as supernovae in the simulations before turning into black holes, whereas stars greater than 40 solar masses become black holes at the end of their lives without turning into supernovae.

From their simulations, Tescari et al. found that at the highest redshift they explored ($z = 6.8$), differing levels of feedback did not materially affect the star formation rate, though there was a mismatch between the simulation and observations if there was no feedback at all. From these results, the team concluded that feedback effects are crucial to understanding galaxies at very high redshifts.

Differences in feedback show up in the lower-redshift simulations, and become important at $z < 5$. Indeed at lower redshifts, the key combination to match the simulations to observed results was strong galactic winds and efficient AGN feedback. For shaping the low star formation rate tail, AGN feedback was more important than galactic winds – and the opposite was true for the high star formation rate tail.

Of particular interest is that in all the simulations, the choice of initial mass function for the stars plays a minor role in the overall evolution of star formation rate density. In addition, while the selection of metal cooling increases the star formation rate density at all redshifts (up to a factor of 2 at $z = 3$), cooling is less important than galactic winds or AGN feedback.

Based on the results of their simulations, the team has concluded that supernova-driven winds are a key factor in determining the shape and evolution of the star formation rate function. Their paper *"Simulated star formation rate function of $z \sim 4 - 7$ galaxies from the ANGUS project"* was accepted for publication in *Monthly Notices of the Royal Astronomical Society* in December 2013.

THE DYNAMIC UNIVERSE

Theme Leader: Professor Matthew Bailes | Swinburne University of Technology

Theme Scientist: Dr Steven Tremblay | Curtin University

Despite its huge age and vast size, the Universe is a changing and violent place. These changes provide us with a unique window into the fundamental physical processes that drive the evolution of the cosmos.

The main focus of CAASTRO's Dynamic Universe theme is to deliver the first all-sky census of the variable and transient sky coordinated between both radio and optical wavelengths. We are carrying out all-sky surveys for radio variability with the Murchison Widefield Array (MWA), the Australian Square Kilometre Array Pathfinder (ASKAP), the Parkes telescope and the Square Kilometre Array Molonglo Prototype (SKAMP), all accompanied by continuous monitoring of the southern optical sky using SkyMapper. These surveys combined are allowing us to study the changing sky over a wider field of view, at higher sensitivity and over a wider range of time scales than has ever previously been possible.

As we prepare for these major new activities, there remains a pressing need to understand the relevant source populations, to test our source-finding and classification algorithms, to build our multi-wavelength expertise, and to establish the relevant international collaborations needed to trigger other observations and to access other data sets. CAASTRO researchers are therefore also pursuing a broad program of archival analyses and new observations, aimed at studying new areas of phase space for variables and transients. By developing innovative techniques to detect weak signals in large data sets, CAASTRO is positioning Australia to capitalise on the powerful capabilities that will eventually be presented by the Square Kilometre Array.

Two Different Populations of Gamma-Ray Bursts

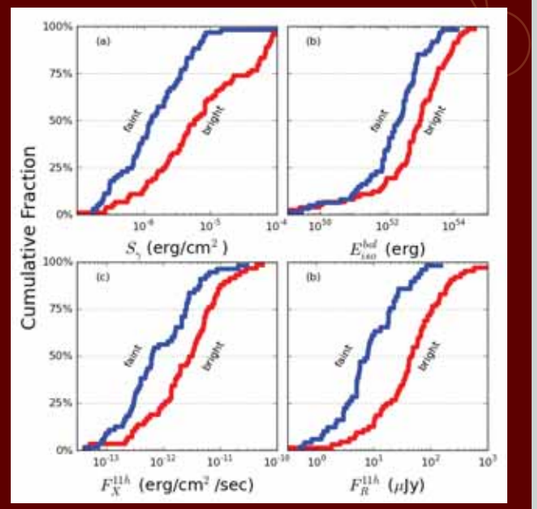
Gamma-ray bursts, generally thought to result from the collapses of massive stars, are the most energetic events that we know of in the Universe. While the gamma-ray emissions themselves are short-lived, there is usually an afterglow at optical and x-ray wavelengths that lasts for up to a few days, as well as a radio afterglow that can be detectable for up to several months. However, only around 30% of gamma-ray bursts have detectable radio afterglows, a low rate that has been attributed to limited observing sensitivity.

CAASTRO researchers Paul Hancock, Bryan Gaensler and Tara Murphy decided to test whether limited sensitivity is indeed the reason why many gamma-ray bursts are not seen at radio wavelengths. They began by first exploring whether the low radio detection rate could be a function of redshift, whereby the "radio bright" gamma-ray bursts might be relatively closer to us than "radio faint" gamma-ray bursts. By looking at the redshift data for some 304 gamma-ray bursts (of which only 95 had a confirmed radio afterglow), they found that there was no significant difference in the redshift distributions of radio-bright versus radio-faint gamma-ray bursts.

The team then considered the role of observational sensitivity. Using a technique they had previously developed known as "visibility stacking", Hancock et al. created separate stacked observations for radio-bright and radio-faint gamma-ray bursts. These stacked observations were considerably more sensitive than the original individual observations, leading to upper limits on detectability that were 4 to 8 times deeper than any previous experiment.

Despite this improved sensitivity, the team were still unable to detect any radio emission from radio faint gamma-ray bursts. This result is inconsistent with the prevailing notion that radio faint gamma-ray bursts are just the low-luminosity tail of a broad distribution of radio fluxes for the overall gamma-ray burst population. Since there is a clear difference in the mean fluxes of radio bright and radio faint gamma-ray bursts, it suggests that the two groups are intrinsically distinct populations.

By looking at the properties of these two populations of gamma-ray bursts at other wavelengths, the team found additional significant differences between the radio bright and radio faint bursts, with the radio bright population also being brighter at X-ray and optical wavelengths. Hancock et al. propose that the two populations, bright and faint, correspond to a bimodal distribution in the efficiency with which gamma-rays are produced by a gamma-ray burst, with radio faint gamma-ray bursts having a high gamma-ray efficiency, thus leaving less energy for afterglow emission at other wavelengths. Their paper "*Two Populations of Gamma-Ray Burst Radio Afterglows*" was published in October 2013 in *The Astrophysical Journal*.



The cumulative distribution functions for gamma-ray bursts with radio bright versus radio faint afterglows. Shown are (a) gamma-ray fluence, (b) isotropic energy release, (c) X-ray flux at 11 hours, and (d) optical flux at 11 hours. Each shows a significance difference between the two populations of gamma-ray bursts.

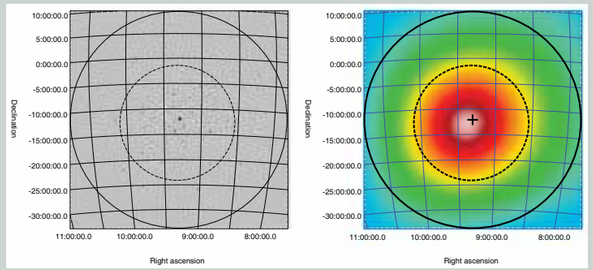
Credit: ***Hancock et al.***

A Low Frequency Survey with the MWA-32T for Variable Sources

Low radio frequency studies rarely conduct blind surveys for variables and transients. These programs instead tend to concentrate on studying known bright sources. Those few blind surveys that have been performed have typically shown little variability in the relatively small number of sources able to be studied.

A large team, led by CAASTRO postdoctoral researcher Martin Bell, has used the Murchison Widefield Array 32-tile prototype to undertake snapshot observations of a field centred on the radio galaxy Hydra A to search for transient and variable radio sources. Four short-duration variable sources were found, displaying relatively low variability on time scales of minutes to days. On time scales of a year, a further two variable sources were also detected. While instrumental or ionospheric effects cannot be excluded for the short-term variable behaviour, the slowly varying sources appear to exhibit either intrinsic variability or refractive scintillation. No transient sources were detected during the observations, and the team used this result to place new upper limits on the number of low frequency transient sources over the whole sky.

The study was also an opportunity to successfully test the functionality and stability of the VAST (Variables and Slow Transient) pipeline, which is being used to analyse the data from MWA. With the full 128-tile system, Bell and his team expect to be able to monitor the time behaviour of tens of thousands of radio sources, thus enabling a significant assessment of the variability of low frequency radio sources in the southern sky. Their paper "*A survey for transients and variables with the Murchison Widefield Array 32-tile prototype at 154 MHz*" was accepted in Nov 2013 for publication in *Monthly Notices of the Royal Astronomical Society*.



A 5-minute snapshot observation of Hydra A taken on 22 March, 2010. The left panel is without primary beam correction. The right panel shows the primary beam correction, with the location of Hydra A shown as a black cross. The dashed line denotes the approximate region of half-power and the solid line denotes the field of view considered by Bell et al.

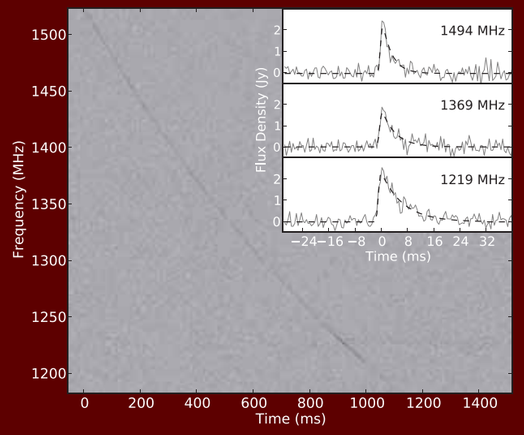
Credit: ***Martin et al.***

Studying New Extragalactic Radio Bursts

CAASTRO researchers Matthew Bailes, Ben Barsdell, Ramesh Bhat, Andrew Jameson, Michael Kramer and Willem van Straten were involved in the discovery of four isolated bursts of radio emission, found during the course of the High Time Resolution Universe survey being conducted with the 64-metre Parkes radio telescope.

In a study led by University of Manchester PhD student Dan Thornton, the millisecond-duration bursts (dubbed "fast radio bursts") were detected in data obtained in 2011 and 2012, and were all located more than 40 degrees from the Galactic plane. The properties of the signals implied that the bursts originated at cosmological distances – radio signals at lower frequencies arrived significantly later than at higher frequencies, due to the lower frequency waves being slowed by the substantial number of intergalactic electrons along their path. The team's modelling of potential host galaxies and of the intergalactic medium suggests redshifts for these bursts of 0.5 to 1. At such distances, the radio bursts are more powerful than any other transient radio source. However, no corresponding gamma-ray or X-ray signals have been identified in association with these bursts.

The physical origin of these signals remains a mystery. One possibility is a connection with strongly magnetised neutron stars, known as magnetars, some of which emit giant flares that produce associated radio bursts. The team's paper *"A Population of Fast Radio Bursts at Cosmological Distances"* was published in July 2013 in *Science*.



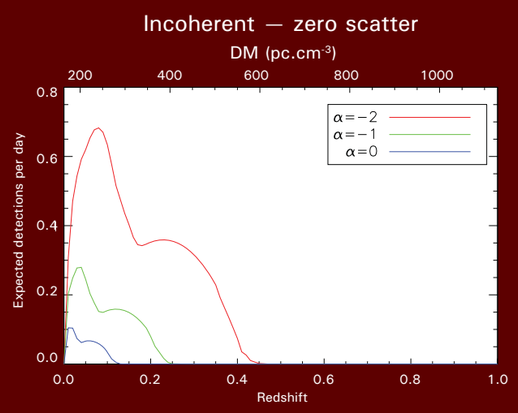
A greyscale of fast radio burst FRB 110220, the brightest burst detected with the Parkes radio telescope, showing the characteristic frequency-dependent delay expected. In the inset, the pulse profile is shown as a function of frequency for various sub-bands, demonstrating the expected increase in pulse width due to scattering in intervening gas.

Credit: ***Thornton et al.***

Following on from the above discoveries, CAASTRO researchers Cathryn Trott, Steven Tingay and Randall Wayth have explored the possibility of detecting fast radio bursts with the Murchison Widefield Array. With its low radio frequencies and large number of antennas, the MWA can monitor a large fraction of the sky (a field of view of approximately 1000 square degrees) at any one time, giving it a significant advantage over other radio telescopes.

Detection of fast radio bursts by the MWA will be very important. First, thus far all detections of fast radio bursts have been made using just one telescope (Parkes), and hence detections with the MWA would rule out any instrumental bias. In addition, MWA's good angular resolution will allow us to narrow down the location of these fast radio bursts, which will greatly assist with the identification of progenitor objects and host galaxies.

Although there has only been a very small number of fast radio burst detections, Trott et al. have modelled the expected number of detections that could be made by the MWA, taking into account uncertainties such as the true occurrence rate of these events and the sensitivity fluctuations that prevent events being discovered near the detection threshold. They conclude that the MWA should be able to detect several events per month. Success in this experiment will enable astronomers to begin conducting a census of this exciting new phenomenon, while fewer realised detections will provide constraints on the underlying event rate and the nature of the intervening intergalactic medium. Their paper *"Prospects for the Detection of Fast Radio Bursts with the Murchison Widefield Array"* was published in *The Astrophysical Journal Letters* in October 2013.



The expected number of detections per day per z = 0.01 redshift bin for the Murchison Widefield Array, using an incoherent combination of signals from each of the 128 tiles. Rates are shown for three values of the source spectral index alpha.

Credit: Trott et al.

The Nature of Peculiar Supernovae

A core issue in the understanding of supernovae is the nature of their progenitors. What is the chemical composition of these stars? Are they binary stars? What are the mechanisms by which they explode?

Widefield optical surveys such as the Catalina Real-Time Transient Survey, the Palomar Transient Factory and the Panoramic Survey Telescope and Rapid Response System have not only discovered hundreds of supernovae in recent years, but have also found new types of transients in relatively unexplored regions of galaxies. One such group of unusual supernovae has been found to display prominent calcium lines in the nebular phase of the explosion. However, no model put forward to date has been able to explain all the features of this type of supernovae.

Taking a different approach to previous studies, CAASTRO's Fang Yuan, Brian Schmidt, Stuart Sim and Richard Scalzo, along with others, have carried out a study of the locations of these "calcium-rich" supernovae within their host galaxies, to see if any information can be ascertained about the corresponding progenitor stars. In addition to their strong calcium spectral lines, these supernovae were typically characterised by moderately faint peak luminosities, relatively fast rises and decays in brightness, normal photospheric velocities, and quick spectral transitions into the nebular phase.

The supernovae studied by Yuan et al. all tend to be located at considerable distances from their host galaxies. In these outer regions, the surface brightness of the host galaxy is quite low, preventing any direct measurement of the properties of the surrounding stellar population.

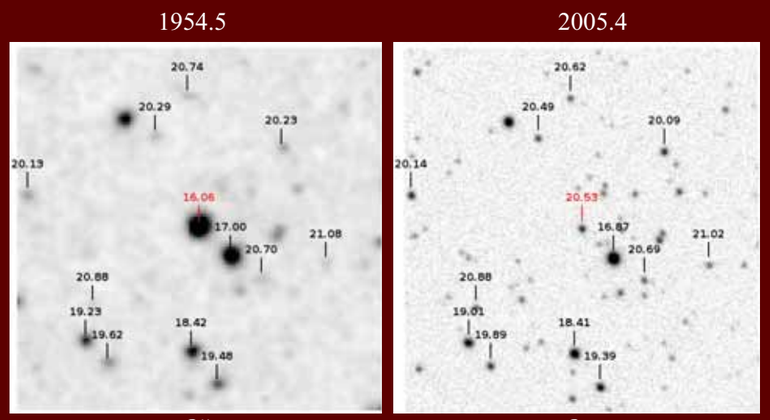
The distances of these peculiar supernovae from their host galactic centres are consistent with origins in globular clusters. However, deep imaging of several of the host galaxies did not reveal any evidence for a typical globular cluster at the supernova location. Furthermore, modelling by the team suggested that if these events had occurred within globular clusters, there should have been a wider range of progenitor masses and supernova luminosities than observed.

Yuan and her team have therefore hypothesised that these calcium-rich supernovae originate from very metal-poor stars. To test this, she compared the spatial distributions of these supernovae with simulations that include star formation and chemical enrichment. Taking into account the possibility that the supernova progenitors may have been very old and thus wandered far from their birthplaces, and also noting that there is a scatter in the metallicity distribution function for a given radius in galaxies, the team compared the distribution of the locations of the supernovae with the simulated distribution of stars of known metallicity. From this analysis, they found that extremely metal poor stars older than 10 billion years would be expected to be found at similar locations in galaxies to the sample of calcium-rich supernovae under consideration.

In the future, as surveys uncover more of these unusual classes of objects, Yuan's approach shows that we will also be able to learn more about their progenitors. Her paper *"Locations of Peculiar Supernovae as a Diagnostic of Their Origins"* was published in June 2013 in *Monthly Notices of the Royal Astronomical Society*.

The observed distribution of peculiar supernovae within galaxies, compared to those of stars of different metallicity and older than 10 billion years, as predicted by the team's simulation. The full sample of supernovae studied is in the top panel. In the bottom panel, the shaded area represents the contour for the five best-studied supernovae in the sample.

Credit: ***Yuan et al.***



These two images, one from 1954 and the other from 2005, show a previously unknown variable star. Recalibrated magnitudes are shown in each image. The object labelled in red has decreased in brightness by 4.5 magnitudes between the observations. The extent of the object's change in brightness, its extremely red colour and its high infrared brightness all suggest that it is a Mira variable.

Credit: ***Madsen and Gaensler***

A New Photometric Catalogue of the Northern Sky

A key science driver for CAASTRO is the exploration of the variable optical sky. Many surveys have begun or are about to see first light, but despite their unprecedented sensitivity and sky coverage, the duration of the survey sets a fundamental limit on the time scales over which variability can be studied. While there are stellar catalogues from earlier epochs, their photometric precision is typically poor.

CAASTRO's Greg Madsen and Bryan Gaensler have now greatly improved our understanding of the variable optical sky on long time scales by recalibrating the USNO-B (United States Naval Observatory) catalogue, which contains data going back to 1949, and combining it with the modern and ongoing Sloan Digital Sky Survey.

The USNO-B catalogue, sourced from 7435 Schmidt plates that were taken from the 1940s through to 2002 from the Palomar Observatory Sky Survey, ESO/SERC, and the Anglo-Australian Observatory UK Schmidt surveys, contains more than a billion objects over the entire northern and southern skies. It was preferred by Madsen and Gaensler over other historical catalogues because of its wider range of epochs and sky coverage, higher threshold for rejecting spurious artefacts, and survey and plate metadata for almost every object in the catalogue.

Madsen and Gaensler developed computer algorithms to match objects from the USNO-B Catalog with the Sloan Digital Sky Survey Catalog. The resulting combined USNO-B/Sloan catalogue contains around 44 million stars and galaxies over more than 14,500 square degrees of the sky. With two epochs of photometry, comprising up to 5 different wavelength bands, recalibrated to an accuracy of ~0.1 magnitude, the new catalogue represents a very accurate repository of photometric data.

Madsen and Gaensler were then able to use their catalogue to identify approximately 250,000 stars and quasars whose brightnesses had changed significantly between the various epochs of the catalogue; virtually all of these varying objects are newly discovered, and are not listed in any other catalogues of variable stars. Their paper "*A Precision Multi-Band Two-Epoch Photometric Catalog of 44 Million Sources in the Northern Sky from Combination of the USNO-B and Sloan Digital Sky Survey Catalogs*" was published in December 2013 in *The Astrophysical Journal Supplement Series*. Future versions of the catalogue will incorporate other current surveys such as PanSTARRS for the northern sky and SkyMapper in the southern sky to complete the all-sky coverage.

THE DARK UNIVERSE

Theme Leader: Professor Brian Schmidt | Australian National University

Theme Scientist: Assistant Professor Chris Springob | ICRAR / University of Western Australia

Over the past decade, astronomers have arrived at the uncomfortable conclusion that 95% of the Universe is not made of normal atomic matter, but consists of two separate as-yet unexplained phenomena: "Dark Energy" and "Dark Matter". The current standard model to describe the Universe is one where the cosmos is geometrically flat, and is dominated by Einstein's cosmological constant, Λ (perhaps corresponding to the vacuum energy of empty space), and by cold dark matter (CDM, widely assumed to be an undiscovered class of massive particle). A series of landmark experiments, several of which were performed by CAASTRO's investigators, have confirmed many of the predictions of "ΛCDM" cosmology. However, fundamental doubt remains over the validity of ΛCDM, because there is no physical understanding of either Dark Matter or Dark Energy. Through CAASTRO, we are carrying out a series of coordinated wide-field surveys of the sky, aimed at rigorously testing the ΛCDM paradigm.

First, we are searching for Type Ia supernovae, using two complementary strategies that will discover these supernovae both in the local Universe and at large distances. Statistics on the relative brightness of nearby and distant explosions can allow a precise measurement of the rate at which the Universe's expansion is accelerating due to Dark Energy, providing the most precise test yet of ΛCDM cosmology.

Second, we are performing all-sky measurements of large numbers of galaxies in both the radio and optical bands, in order to derive precise estimates of their distances, velocities and 3D distributions in space. Combining this information with a substantial new body of simulations and theoretical tools that we are developing, we aim to measure the density and velocity fields of galaxies over a huge volume. With these data we can measure the subtle variations in the otherwise smooth expansion of the Universe that are a specific prediction of ΛCDM, thereby deriving a map of Dark Matter on the largest scales ever performed. We can use these observations of large scale structure and cosmic flows to test Einstein's theory of gravity in the weak field regime, to test whether Cold Dark Matter behaves as predicted, and to determine whether structure in the Universe is growing as expected for a cosmos filled with Dark Energy in the form of a cosmological constant.

Spectroscopic Studies of a Nearby Supernova

In measuring the expansion history of the Universe, type Ia supernovae (thought to be the explosions of carbon-oxygen white dwarfs in binary systems) are key "standard candles" for distance measurements at high redshifts. Such supernovae were used by the team led by CAASTRO's Brian Schmidt in the 1990s to determine that the Universe was expanding at an increasing rate due to Dark Energy. However, it is not yet clear if all type Ia supernovae have a common origin or explosion mechanism, and this remains a key issue for the use of type Ia supernovae in precision cosmology.

A core activity within CAASTRO's Dark Universe research theme is the undertaking of wide surveys to discover nearby Type Ia supernovae, and then to compare them with more distant ones to refine the Universe's expansion rate. Spectroscopic studies of large samples will help to better understand the diversity of type Ia supernovae, while at the same time in-depth studies of individual supernovae can help to better understand the nature of the stellar explosions themselves.

Contributing towards the latter, an international team headed by CAASTRO's Michael Childress (and also including Richard Scalzo, Stuart Sim, Fan Yuan and Brian Schmidt) has undertaken the largest ever collection of spectroscopic data on a type Ia supernova.

The supernova, designated SN 2012fr, was discovered on 27th October 27, 2012, in the nearby galaxy NGC 1365 using the robotic 0.25-metre TAROT telescope in La Silla, Chile. The following day, a CAASTRO-led team from the Australian National University obtained a spectrum of the supernova with the Wide Field Spectrograph (WiFeS) on the ANU 2.3-metre telescope at Siding Spring Observatory, New South Wales. Their data revealed that the supernova was of the type Ia class, that the supernova had been discovered within a day of the explosion, and that it would be a further two weeks before it would peak in brightness.

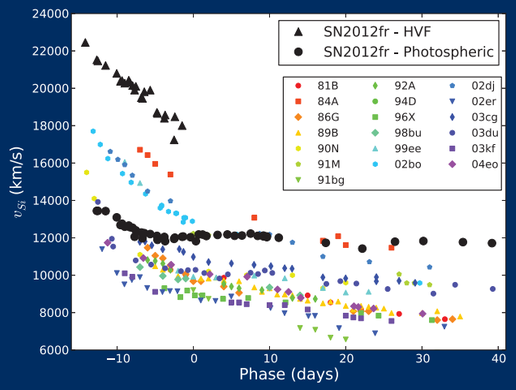
This first spectrum marked the beginning of an intensive program of photometric and spectroscopic observations aimed at following the progress and evolution of SN 2012fr. In addition to the data taken at Siding Spring Observatory, the team obtained spectra from a number of observatories around the

world: the 3.6-metre NTT telescope in La Silla, Chile; the South African Large Telescope; the 1.9-metre South African Astronomical Observatory telescope; the 3-metre Shane telescope at Lick Observatory, USA; the 2.5-metre Irenenee du Pont telescope and 6-metre Magellan-Baade telescope at Las Campanas Observatory, Chile; and the 2.5-metre Nordic Optical Telescope at La Palma, Canary Islands. The worldwide coverage meant that at least one spectrum was taken of SN 2012fr every night from the day after its discovery until nearly two weeks after the supernova had reached maximum brightness.

Childress' analysis of the supernova's spectrum revealed silicon and iron layering in the ejecta of the explosion to an extent never previously seen, with one thick silicon outer layer that faded by the time of peak brightness of the supernova, plus an inner layer that hardly changed for several weeks. The silicon spectral line is among the most prominent in type Ia spectra, and is a key tool in the characterisation of the diversity of type Ia supernovae.

The discovery of a type Ia supernova in the galaxy NGC 1365 is additionally significant, because NGC 1365 was one of the galaxies included in the Hubble Space Telescope Key Project (a study to narrow down the value of the Hubble constant and hence the expansion rate of the Universe). The distance to NGC 1365 is known quite accurately through the observations of Cepheid variable stars in this galaxy. Only eight type Ia supernovae with well-observed light curves had previously been discovered in galaxies with independent distance measurements arising from Cepheid variables, and of those eight, only three had been in galaxies closer than NGC 1365. Because SN 2012fr was a relatively normal type Ia supernova (albeit with several interesting features), it is an ideal candidate to measure the peak intrinsic luminosity of type Ia supernovae, and thus to further constrain the value of the Hubble constant.

The paper by Childress et al., "*Spectroscopic observations of SN 2012fr: A luminous normal type Ia supernova with early high-velocity features and a late velocity plateau*", was published in *The Astrophysical Journal* in June 2013.



The velocity evolution of the Si II λ6355 feature of Supernova 2012fr compared to that of a number of type Ia supernovae from a previous sample. The high-velocity feature component of SN 2012fr is shown as large black triangles, while the lower velocity photospheric component is shown as large black circles.

CREDIT: Childress et al.

Extending the Tully-Fisher Relation for Galaxies in Mid-Infrared

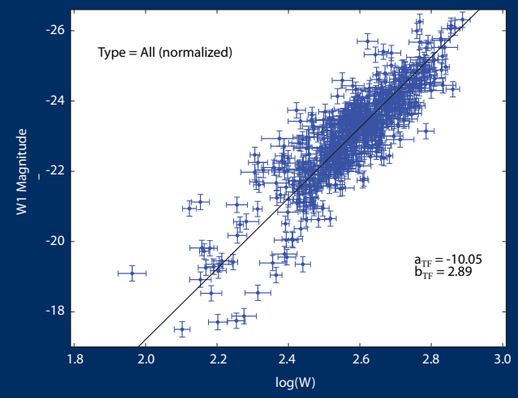
The Tully-Fisher relation, first published in 1977, is a way of estimating distances to distant galaxies, independent of their redshifts. It describes a correlation between the total luminosity of a spiral galaxy and its rotational velocity – the brighter a galaxy is, the faster it rotates. Based on optical wavelength data, the Tully-Fisher relation was restricted in use due to factors such as dust extinction and scattering, leading to large uncertaintes. However, subsequent studies have shown that the dispersion in the Tully-Fisher relation can be reduced by moving to infrared wavelengths.

Utilising data from the Wide-field Infrared Survey Explorer (WISE) satellite, CAASTRO researchers David Lagattuta, Jeremy Mould, Lister Staveley-Smith, Tao Hong, Christopher Springob and colleagues have extended the Tully-Fisher relation into the mid-infrared range. WISE imaged the entire sky at mid-infrared wavelengths ranging from 3.4 to 22 microns. At the upper end of mid-infrared wavelengths, it has been found that the luminosity of a galaxy primarily comes from warm dust and gas as opposed to stars themselves. The variable distribution of dust in galaxies means that Tully-Fisher relations formed from long mid-infrared wavelengths can show increased scatter. As such, the team only looked at the 3.4-micron data where, for a typical star-forming galaxy, only 1% to 5% of the emission is due to dust.

In compiling an infrared database of galaxies for their Tully-Fisher study, the team first cross-matched magnitudes from the WISE all-sky data release catalogue with rotational velocity measurements from the 2-Micron All Sky Survey (2MASS) Tully-Fisher all-sky galaxy catalogue. The initial data set was then filtered to include only 568 spiral galaxies with the highest-quality rotational velocity data and with inclination angles greater than 45°.

Corrections were then applied to the galaxy data. Initially, luminosity corrections were made for each galaxy's distance, its peculiar velocity, and for dust extinction both within the Milky Way and in the galaxy itself; for rotational values, corrections were made for such factors as instrumental systematic effects and galaxy inclination. After then adjusting for the differing morphologies of the galaxies, the team derived a precision mid-infrared Tully-Fisher relation. This new Tully-Fisher relation can be used to measure the peculiar velocities of galaxies that, for a large enough sample, can then provide constraints on the distribution of Dark Matter in the local Universe.

Lagattuta's paper "*WISE TF: A Mid-infrared, 3.4 mm Extension of the Tully-Fisher Relation Using WISE Photometry*" was published in *The Astrophysical Journal* in July 2013.



The WISE mid-infrared Tully-Fisher relation after all the galaxies in the sample have been normalised to an Sc/Sd morphology.

CREDIT: Lagattuta et al.

Testing Cosmological Models with Peculiar Velocity Surveys

One of the key questions in cosmology is whether the Lambda-Cold Dark Matter (ΛCDM) model can fully account for both the accelerated expansion of the Universe and the growth of large-scale structure. In the past, testing these theories has primarily been through redshift surveys.

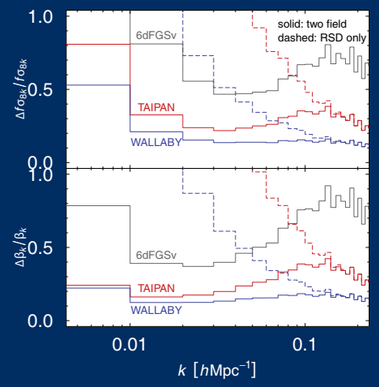
Peculiar velocity surveys – which measure the velocity of a galaxy relative to that caused by the Universe's expansion – have an advantage in that once we have measured the peculiar velocity directly, we can compare it to the peculiar velocity we would predict based on the surrounding galaxy distribution. This relation between velocity and density can provide strong tests of the ΛCDM model, by measuring the linear growth rate of large-scale structures at low redshift. Various proposed models of Dark Energy or modified gravity give different growth rates, depending on the time or scale. Studies of low redshift galaxies are significant in testing the ΛCDM model, as it is during this epoch of the Universe that the ratio of Dark Energy density to critical density is the largest. As such, any deviation from the ΛCDM model would be the most significant at these times.

Jun Koda has led a team including CAASTRO researchers Chris Blake, Tamara Davis, Christopher Springob, Morag Scrimgeour, Andrew Johnson and Lister Staveley-Smith, to explore whether upcoming peculiar velocity surveys will be competitive with redshift surveys. The team reviewed models for the auto- and cross-power spectra of galaxy number density and line-of-sight velocity in redshift space. By introducing a new damping term to the equations, they were able to improve the model by countering strong redshift-space distortions in these spectra.

There are several planned forthcoming peculiar velocity surveys that Koda et al. studied using their Fisher matrix confidence interval forecasts for correlated fields of galaxy density and velocity. TAIPAN (Transforming Astronomical Imaging surveys through Polychromatic Analysis of Nebulae) will build on the 6dF Galaxy Survey using an upgraded spectrograph on the ANU's UK Schmidt Telescope at Siding Spring. The team generated mock galaxies for TAIPAN that were similar to those observed in the 6dF Galaxy Survey; based on the four-fold increase in the number of redshifts expected from TAIPAN compared to 6dF, they found that the constraints on the cosmological growth rates will be a factor of 2 better than those from 6dF.

WALLABY (the Widefield ASKAP L-band Legacy All-sky Blind surveY) and WNSHS (Westerbork Northern Sky HI Survey) are two planned surveys at radio wavelengths using the Australian SKA Pathfinder radio telescope in Western Australia and the Westerbork Synthesis Radio Telescope in the Netherlands respectively. Koda et al. found that these surveys will constrain the growth rate with 3% precision for low redshifts, $z < 0.05$.

Koda's work shows that peculiar velocity surveys will provide competitive growth rate measurements at redshifts below 1. The next step is to develop the detailed theory of velocity power spectrum in redshift space, which will allow for accurate parameters to be derived from future peculiar velocity surveys. The team's paper *"Are peculiar velocity surveys competitive as a cosmological probe?"* was accepted in December 2013 for publication in *Monthly Notices of the Royal Astronomical Society*.



Predicted constraints on cosmological parameters $f\sigma_8$ and β for different data sets. The plots show how redshift surveys constrain the linear growth rate, amplitude of matter perturbations and galaxy bias as a function of inverse scale, k, for the 6dF Galaxy Survey velocity subsample (6dFGSv, grey line), the TAIPAN survey (red lines), and for the combination of the WALLABY and WNSHS 21cm radio surveys (blue lines). Dashed lines are for redshift samples, and solid lines are for peculiar velocity subsamples. Peculiar velocity surveys improve the constraints for $k < 0.1$, because they are not limited by the cosmic variance.

CREDIT: Koda et al.

Investigating Dark Matter Annihilation

Dark Matter makes up most of the mass in the Universe. However, its nature still remains a mystery, despite the many experiments that have suggested indirect detection or even hinted at direct detection of this elusive phenomenon.

In the search for other ways of detecting and understanding more about Dark Matter, CAASTRO affiliate Katherine Mack has explored the possibilities of detecting the annihilation of Dark Matter through its effects on the local environment in galactic haloes. While the detection of such Dark Matter annihilation will depend on local factors such as redshift, density, temperature and ionisation state, Mack has addressed the question of just how much annihilation energy is produced by Dark Matter haloes at a given redshift. Knowing this will not only help researchers look for times in the Universe's history when Dark Matter annihilation may have been higher and thus more visible than at the present time, but also can also shed light on how Dark Matter annihilation has contributed to the evolution of matter in the Universe.

Mack considered two components of the rate of Dark Matter annihilation – a smooth component for uncollapsed dark matter halo areas, plus a structured component for collapsed halos.

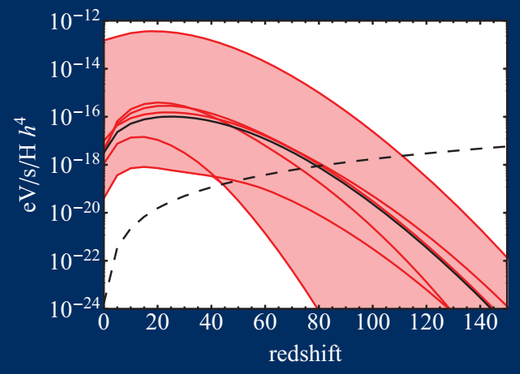
Considerable uncertainties exist in models for the particle properties of Dark Matter, the halo mass function, the minimum and maximum mass cut-offs, the halo density profile and the mass-concentration relation, all of which are needed for calculating the annihilation rate of Dark Matter in collapsed structures. Mack addressed these uncertainties and their magnitudes to demonstrate the effects on estimates of the Dark Matter annihilation power.

Calculation of the energy output from Dark Matter annihilation requires knowledge of the lower limits of mass for collapsed structures. Just how low that is remains uncertain, due to unknowns about the nature, mass and lifetimes of Dark Matter particles, but Mack's modelling has shown that even the annihilation from the smallest mass haloes makes a significant contribution to the total power output, whereas the most massive Dark Matter halos are quite rare and so do not have a large effect.

For the structured component of Dark Matter annihilation, Mack found that power peaks around the time of primordial star formation, corresponding to redshifts between 10 and 40. During this time, the power output of the structured component is around four orders of magnitude stronger than the smooth component. This has significant implications for star formation and reionisation occurring at this time.

Important questions remain in predicting the range of Dark Matter annihilation power, regarding the form of the Dark Matter mass function, the mass of the smallest collapsed Dark Matter haloes and their longevity, and the evolution of Dark Matter density as a function of mass and redshift.

Mack's paper *"Known Unknowns of Dark Matter Annihilation Over Cosmic Time"* was accepted in late 2013 for publication in *Monthly Notices of the Royal Astronomical Society*.



A plot of mean power output per hydrogen nucleus from the annihilation of Dark Matter as a function of redshift. The black solid line is the fiducial model from Mack's paper, with other possible models represented by the red solid lines. The black dashed line corresponds to annihilation from the smooth component. The red shading represents the range of annihilation power predictions corresponding to the models considered in the analysis.

CREDIT: Mack

DISCOVER

Lyman-alpha Galaxies as a Cosmological Tool

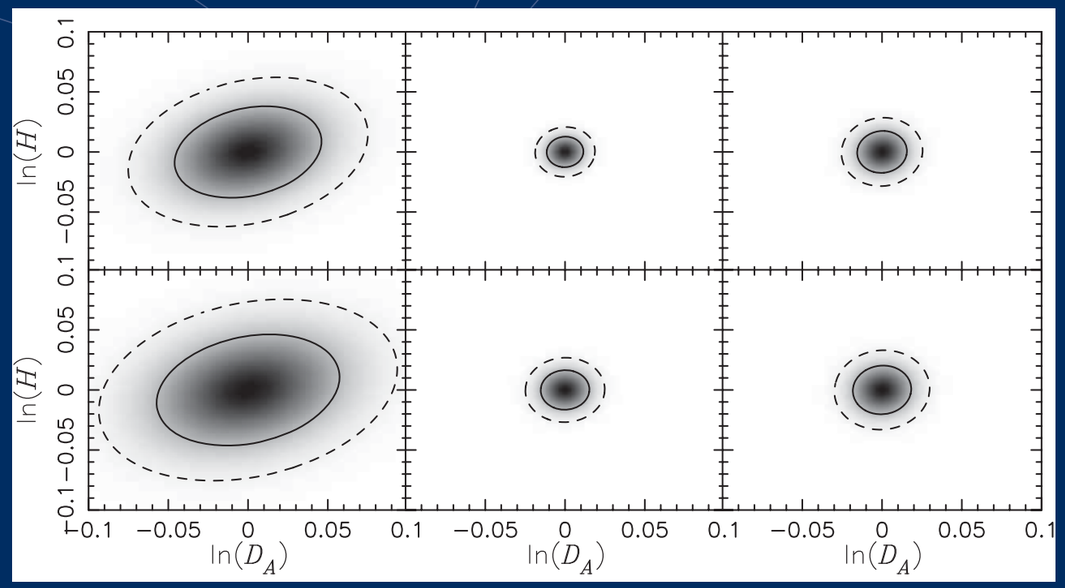
In testing competing models in cosmology, astronomers consider both low and high redshifts. At low redshifts, models can be tested as a function of scale, while for high redshifts one can test a model's predictions for how things should evolve with time. Galaxy redshift surveys are typically restricted to low redshifts due to both the faintness of galaxies and the larger volume required for a high-redshift survey.

Lyman-alpha galaxies are detectable at high redshifts, due to their strong emission lines. Although the number of Lyman-alpha galaxies has grown recently, this has still been insufficient for testing cosmological models. However, that will change with the forthcoming Hobby-Eberly Telescope Dark Energy Experiment (HETDEX), a survey that will use the 11-metre Hobby-Eberly Telescope at McDonald Observatory in Texas. Designed to measure the redshifts of approximately 800,000 Lyman-alpha galaxies at redshifts between 1.9 and 3.5, HETDEX will use the clustering of Lyman-alpha galaxies to measure two cosmological distance scales, the angular diameter distance and the Hubble rate, both as a function of redshift.

One big challenge for HETDEX is to properly account for the ways in which radiative transfer affects the strength of Lyman-alpha emission from distant galaxies. In particular, line-of-sight gradients in the peculiar velocities of Lyman-alpha galaxies and fluctuations in the ultraviolent radiation field can both affect the observed clustering of such galaxies to such an extent that they can mimic the effect of gravitation within the clusters.

CAASTRO researchers Bradley Greig and Stuart Wyithe, along with Eiichiro Komatsu (Director, Max-Planck Institute for Astrophysics, Garching, Germany), have investigated the non-gravitational effects on Lyman-alpha emission from high-redshift galaxies, and have developed ways in which cosmological parameters can be recovered in the presence of these factors. Specifically, they showed that both the cosmological and Lyman-alpha radiative transfer parameters can be derived from a HETDEX-type survey by combining the power spectrum with a three-point correlation function, known as a "bispectrum". While the power spectrum only gives the amplitude of the fluctuations in the growth of large-scale structure, the bispectrum also provides information on how the structure formed, thus distinguishing between gravitational and non-gravitational effects.

The team then calculated the Fisher matrix for a HETDEX-type survey to derive the expected cosmological parameter constraints. By taking into account the way in which radiative transfer effects alter the power spectrum and bispectrum of Lyman-alpha-emitting galaxies, Greig et al. concluded that HETDEX will be able to determine the growth rate of large-scale structures at high redshifts to an accuracy of 20% - and to an accuracy of 7% if information on the radiative transfer effects of velocity gradients can be incorporated. Their paper *"Cosmology from clustering of Lyα galaxies: Breaking non-gravitational Lyα radiative transfer degeneracies using the bispectrum"* was published in May 2013 in *Monthly Notices of the Royal Astronomical Society*.

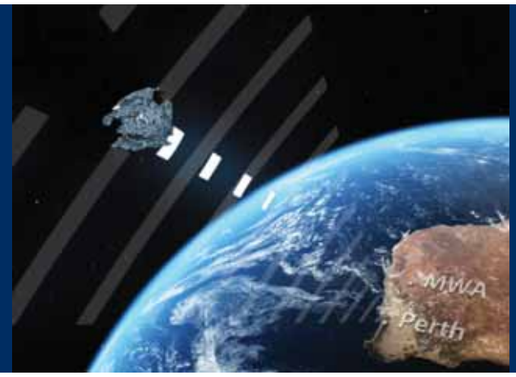


Two-dimensional likelihood distributions for the angular diameter distance, D_A, and the Hubble rate, H, predicted for HETDEX, with 1σ and 2σ likelihoods shown as solid and dashed contours, respectively. From left to right, the columns show the constraints generated only from the Lyman-alpha galaxy reduced bispectrum, from the Lyman-alpha galaxy power spectrum and bispectrum combined, and from the Lyman-alpha galaxy power spectrum and reduced bispectrum combined. The top row shows the fiducial case with no Lyman-alpha radiative transfer effects included, while the bottom row shows the improvement produced when including first-order Lyman-alpha radiative transfer effects.

Credit: Greig et al

CASE STUDIES

The SkyMapper Telescope imaged under the Milky Way.
Credit: James Gilbert (AAO).



FM radio signals reflect off space junk, and then can be detected by the MWA.
Credit: Swinburne Astronomy Productions

Interdisciplinary Research Case Study

WIDE-FIELD RADIO ASTRONOMY ENABLES SPACE JUNK TRACKING

Professor Steven Tingay (Curtin University)

The Murchison Widefield Array (MWA) is the only low frequency precursor telescope for the Square Kilometre Array, and is one of the main new facilities that CAASTRO researchers are using for all-sky astrophysics.

Previous work by CAASTRO student Ben McKinley (Australian National University), using the Moon as a calibration object as part of one of CAASTRO's MWA science programs, revealed that the Moon reflects transmitted radio signals (in this case FM radio transmissions) back to the Earth.

These signals were easily picked up by the MWA, with the result that they dominated the experiment that McKinley and his collaborators were originally trying to execute. However, the work inspired CAASTRO Chief Investigator Professor Steven Tingay to think about what else in the near-Earth space environment would also reflect FM radio waves back to Earth.

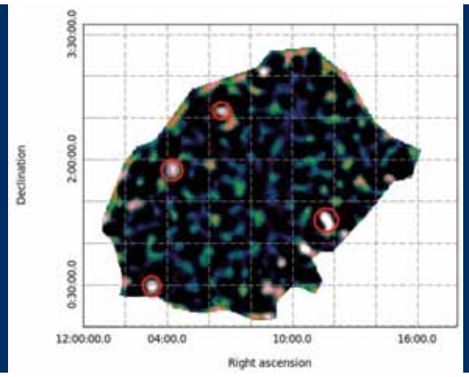
McKinley and Tingay realised that relatively small pieces of space junk in orbit around the Earth should be detectable by the MWA. Moreover, the wide field of view of the MWA means that multiple pieces of space junk should be detectable at any given time.

This realisation was significant, as space junk tracking has become one of the most important aspects of Space Situational Awareness (SSA), and is a globally critical activity that contributes to the protection of civilian and defence satellites worth hundreds of millions or billions of dollars.

The realisation that radio astronomy facilities could be used in this manner opens up a new interdisciplinary approach to SSA, enabled by the instrumentation and algorithmic advances in radio astronomy. As SSA is an enormous international activity involving large amounts of funding, a mutually beneficial relationship between radio astronomy and SSA can be envisaged.

Tingay and McKinley, with other MWA investigators and collaborators from the SSA community, were then motivated to undertake a rigorous study, involving electromagnetic simulations, calculations and observational tests to demonstrate the plausibility of the idea. This CAASTRO-led work was published in *The Astronomical Journal* in 2013. The team determined that pieces of space junk as small as 0.5 metres in size could be detected and tracked at altitudes of up to 1,000 kilometres.

In addition to this CAASTRO research bringing together radio astronomers and the SSA community for the first time, the work has attracted a lot of attention in the media. The general public can understand the concept of space junk and appreciate the need to protect expensive and strategically important satellites that support communications, defence activities, and scientific research. This interdisciplinary work has therefore garnered a lot of positive exposure for CAASTRO, the MWA, and SSA.



TIRF data on insulin uptake transformed into a format readable by radio astronomy applications. Red ellipses are detected uptake events.
Credit: Paul Hancock

Left: CAASTRO/CoEPP Workshop – Jeremy Mould, Signe Riemer-Sorenson, Alan Duffy and Cathryn Trott

Right: CAASTRO/ CoEPP Workshop
Credit: Kim Dorrell

Interdisciplinary Research Case Study

SUPERNOVAE MEET DIABETES

Dr Paul Hancock (University of Sydney/Curtin University)

Researchers at the Garvan Institute are looking at the uptake of insulin in human cells. Glut-4 is one of the proteins within our cells that plays a part in the complex interaction between insulin, glucose and adipose. By combining genes from jellyfish and tomatoes with that of Glut-4, it is possible to make the Glut-4 protein fluoresce when exposed to green or red light. Using a technique called total internal reflection fluorescence (TIRF) microscopy, researchers can then observe the movement of the proteins within the cell. When a Glut-4 protein fuses with the cell wall, it fluoresces much more strongly and produces a bright flash of light that fades over time. Studying the uptake of insulin and transport of glucose within human cells therefore involves detecting these flashes of light.

In a typical experiment, a camera is set up on a TIRF microscope to image a cell that has been exposed to insulin. Over the next few hours, the cell is imaged 10 times per second. The data are then processed over the next week with a series of different computer algorithms and a significant amount of human interaction. Researchers thus spend more time collecting and processing data than they spend analysing and interpreting the data.

Work at The University of Sydney has been underway to prepare for the large amounts of data that will stream from the Australian SKA pathfinder (ASKAP). The ASKAP survey for variable and slow transients (VAST) will search the radio sky for explosive events that are typical of extreme astrophysical processes. In order to understand these events it is necessary to process and analyse data in near real time. An image processing pipeline has been created that will accept images produced by ASKAP, find all the astronomical sources within these images, and then keep track of these sources across multiple images. Most sources will be radio galaxies and Galactic sources that are relatively constant over time, however there will occasionally be new sources that appear, and these are the focus of the Variable and Slow Transients (VAST) survey.

At a meeting in 2013 it was realised that although the science goals were different, researchers at both locations were facing the same data processing problems. Furthermore it was thought that it may be possible to transform the biological data from the Garvan Institute into something that could be recognised by the radio image reduction pipeline that had been built for the VAST project. Initial work has been done to prove that such a conversion is possible. The above figure shows the TIRF data after it has been transformed into the FITS format and displayed in DS9. The red ellipses are the locations of 'sources' detected by the source finding program Aegean. In total 1000 images have been transformed and pushed through the VAST pipeline.

This successful proof of concept work shows that it is possible to use the software developed for radio astronomy research to aid in biomedical research. The events detected by the VAST pipeline will need to be cross-validated with the results obtained from the Garvan Institute. Work will need to be done to determine which transformation parameters will produce the highest quality detections. When this work is complete, it will be possible for biomedical researchers to collect and analyse data in one day that previously took a week. The amount of time saved in data collection and analysis can then be refocused onto diabetes research, saving both time and money.

Interdisciplinary Research Case Study

CAASTRO / CoEPP JOINT WORKSHOP

Dr. Katherine Mack (University of Melbourne)

The goal of the CAASTRO/CoEPP Joint Workshop, held in Melbourne in February 2013, was to get members of both ARC Centres of Excellence (Astrophysics and Particle Physics) into one room for the first time to discuss areas of joint interest. It turned out to be an excellent opportunity to foster discussions and new collaborations and to highlight areas of possible collaboration between the centres.

On the first day of the workshop, a series of talks summarised the current status of studies into dark matter, neutrino physics and astrophysics, dark energy and modified gravity. The second day was devoted to more detailed talks on topics such as inflation, dark matter detection, dark energy theories, and neutrino models.

A recurring theme of the workshop was the need for collaboration between astrophysicists and particle physicists in searches for signs of beyond-the-standard-model physics in cosmology. In each of the major topics, cosmological observations are a vital tool for studying fundamental physics phenomena, and therefore we need to have a complete understanding of the astrophysical backgrounds and foregrounds that might mimic a signal of new physics.

Several of the talks on dark matter discussed the possibility for indirect detection of dark matter annihilation via cosmic ray or gamma ray excesses. Recent findings of excesses by the PAMELA and Fermi satellites (and, since the meeting, the AMS experiment on the International Space Station) could be important clues, but could also be mimicked by emission from pulsars. Neutrino signals could also originate from dark matter interactions, so understanding the possibility to produce neutrinos in astrophysical cosmic ray acceleration is an important step in interpreting the data. Similarly, a measurement of the effective number of neutrino species derived from the cosmic microwave background (CMB) could have implications for early universe models, assuming the astrophysical uncertainties are ironed out.

Dark energy is another area in which the need for collaboration between the physics and astrophysics communities was highlighted. Baryon acoustic oscillations and the growth of structure, both areas of current exploration in CAASTRO, are giving us some of our best constraints on dark energy models. Theoretical studies into dark energy and modified gravity can help motivate and inform future observational efforts. Similarly, the study of inflation and early universe physics, which is a focus of CoEPP via their search for beyond-the-standard-model physics, relies strongly on cosmological data. While CAASTRO is not directly involved in CMB observations, several CAASTRO projects in the Evolving and Dark Universe themes relate to CMB foregrounds that are essential to the interpretation of the data.

One clear outcome of the workshop was that better links between our two centres would be beneficial for the missions of both. The goal of discovering new fundamental physics can only be advanced through collaboration between those studying particle physics at high energies and those with an understanding of the astrophysical effects that can mimic new particle interactions. The joint workshop was a first step in fostering that collaboration; maintaining this dialogue will help both centres to be leaders in the search for new physics and a more complete cosmological model.

Screen capture from the
All Sky Virtual Observatory

MWA
Credit: Emil Lenc

Interdisciplinary Research Case Study

VIRTUAL OBSERVATORY SERVICES FOR SKYMAPPER DATA

Professor Brian Schmidt (ANU) and Dr Yeshe Fenner (Astronomy Australia Ltd)

Modern telescopes optimised for survey-science will generate data in volumes never previously experienced in Australian astronomy. To gain maximum scientific benefit from this flood of data, we need services that make it possible to discover, access, query and explore the data, from any location in the world.

During the last year, the Australian National University (ANU), National Computational Infrastructure (NCI), Swinburne University of Technology (SUT) and Astronomy Australia Ltd (AAL) have been collaborating with industry partner Intersect Australia Ltd to build the All Sky Virtual Observatory (ASVO)*. Intersect is a professional software development company whose technical skills and approach to software project management immediately brought an additional dimension to the skills within the Australian astronomy eResearch community. Intersect has been developing the web interface for ASVO, including building a user-friendly front-end to a suite of data access services developed by ANU/NCI to support the massive petabyte-scale dataset that will be produced by the SkyMapper Southern Sky Survey.

Led by CAASTRO "Dark Universe" Theme Leader and Nobel Laureate Professor Brian Schmidt, the SkyMapper survey will produce the most detailed digitised map of the southern sky at optical wavelengths, making it an important facility for the CAASTRO "Dynamic Universe", "Dark Universe" and "Evolving Universe" Themes. During its five-year survey, SkyMapper will image each part of the sky through six filters at six epochs, detecting more than a billion objects, and generating over 1 petabyte of image data and hundreds of terabytes of catalogue data. The volume and quality of SkyMapper data will enable astronomers to: create a comprehensive census of the stars in the Milky Way; discover the oldest quasars and stars; search for new dwarf galaxy companions to the Milky Way; map the Galaxy's dark matter distribution; and discover variable and transient objects including asteroids, Trans-Neptunian Objects, RR Lyrae stars, and supernovae (up to 50,000 supernovae will be detected and SkyMapper's first supernova discovery already occurred in October 2013).

The SkyMapper survey dataset will be made freely available to the scientific and general community via ASVO, which will also connect the SkyMapper data to the world-wide network of datasets that comprises an International Virtual Observatory. This will enable astronomers to not only access the data, but compare and combine SkyMapper data with other datasets spanning radio, optical, ultraviolet and X-ray wavelengths, along with theoretical data, such as that from ASVO's Theoretical Astrophysical Observatory, developed by SUT with Intersect's involvement.

Our approach in partnering with industry was to let ANU's project scientists and NCI's database specialists focus on their specific areas of scientific and technical expertise, and to outsource expertise where it would optimise efficiency, sustainability and expected uptake of the final product. We chose to work with Intersect as they have a successful history designing software solutions for researchers, and that helped narrow the potential cultural divide that can impact industry-academia partnerships.

* ASVO is funded through the Australian Government and the National eResearch Collaboration Tools and Resources (NeCTAR) Project.

National Research Priority Case Study

SMART INFORMATION USE

Dr André R. Offringa (Australian National University)

The Murchsion Widefield Array (MWA) has begun its highly sensitive observations with 128 tiles. Although it is hosted at one of the most radio-quiet areas in the world, radio-frequency interference (RFI) is still observed, where it can be caused by ionospheric reflections; airborne objects such as aeroplanes and satellites; or local phenomena such as lightning, cars or unshielded equipment. Initial MWA observations show very little RFI, but as the observational sensitivity is increased, it becomes more important to be aware of possible RFI in the data.

The RFI levels need to be monitored effectively into the future, both for the protection of the site and for the rapid identification of corrupt data in the MWA's extremely high data rate. As such, a first step was to perform baseline studies, for the purpose of future comparison and for monitoring the local environment through the ongoing construction activity on the MWA site.

There is much to be learned from the characterisation of the wide range of RFI signals, for the purpose of identifying the originators of the signals, for understanding propagation effects, and for establishing mitigation techniques. These studies are increasingly important with the design and construction of several new low-frequency (~150 MHz) instruments with high sensitivity, including the MWA, PAPER, LOFAR, LWA, and the planned SKA. The current understanding is that with sufficient high time and frequency resolution, and by using accurate detection methods, a radio-quiet site is not a strict requirement, as long as the frequency range of interest is not contaminated by continuous transmitters with a relatively large bandwidth. Such transmitters, which include FM and DAB stations, occupy only a small frequency range of the full bandwidth below 200 MHz. However, these bands can be important for certain experiments, such as for the MWA Epoch of Reionisation project, space weather experiments and for tracking Earth-orbiting space satellites or space junk.

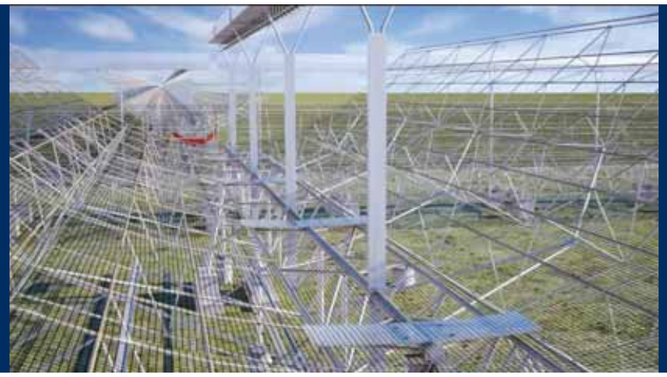
The objectives of this project have been to extensively analyse the impact and properties of RFI on the MWA with different interferometric observing configurations (day/night, frequency range, resolution, etc.); to analyse the observational benefits of building the MWA in a radio-quiet area; to build online tools for the immediate recognition and characterisation of RFI in the MWA bands; to gather statistics that could be incorporated into a permanent RFI monitoring database; and to further develop the best design practices for radio telescopes, such as the number of bits used by the ADC, the strength of poly-phase filters, the optimal time and frequency resolutions and the detection algorithms.

The results will be very useful for understanding MWA data and possibly optimise observing scheduling and configuration. The results are also highly relevant for the design of the low-frequency part of the SKA.

As of the end of 2013, we have successfully implemented LOFAR's RFI detection software into the MWA preprocessing pipeline "Cotter". We are happy to report that almost all MWA observers use this pipeline, and that in almost all cases this has been sufficient to mitigate RFI. Tools have been made available to get a quick overview of the RFI environment.

A full night of 32T MWA data was observed in the night of 17 January 2013 and analysed. This has given us a first baseline of RFI measurements, although unfortunately the configuration of the instrument was not optimal. We were assigned an hour of MWA Director's discretionary time to analyse the RFI environment, and to see the impact of 40 kHz frequency averaging on RFI detection. Analysing these data led to the conclusion that the RFI environment is so benign that frequency averaging is thought to not cause much issues.

Because of the minimal impact of RFI after having implemented the RFI detection pipeline, the current focus has been on other challenges. We intend to repeat RFI measurements nevertheless, because RFI measurements are important for comparisons and the planning of observations. Current RFI efforts have focussed on the impact on imaging. Once the MWA's fast transient mode is operational, further RFI analysis and/or mitigation might be required. There is also much to be learned from RFI measurements for future instruments such as the SKA.



SKA Molonglo Pathfinder (SKAMP)
Credit: Swinburne Astronomy Productions

OzDES Project Launch
Credit: Chris Lidman

National Research Priority Case Study

FRONTIER TECHNOLOGIES

Professor Matthew Bailes (Swinburne University of Technology)

The computer games entertainment industry has driven rapid growth in the computational capacity of commodity graphics cards. These have found their way into the science community via graphics processing units or GPUs. One of the fundamentally important tasks in computer graphics is the ability to convolve images using signal processing techniques that incorporate the Fast Fourier Transform, or FFT. Coincidentally radio astronomy also makes extensive use of the FFT, and the speed of this task has increased exponentially since the 1950s.

One of the fathers of modern radio astronomy, Professor Govind Swarup used a primitive calculator to manually process a 25x25 point FFT in the 1950s and, despite being widely known as a radio astronomy genius, it used to take him 24 hours. Now a $700 graphics card can process a 512 x 16 point FFT over 1,000 billion times more quickly. Thus a modern computer games card is 1,000 times more powerful than the entire world's population for this task!

When the Molonglo Observatory upgrade was first proposed about 10 years ago, the signal processing requirements were mapped to specialist chips that although expensive, could perform enough signal processing to complete the task for about $1 million, which at the time was a bargain. At the time, to process the data with an equivalent number of computers would have cost several million dollars and consumed over 300 kW of power.

Although the deployment of the necessary fibres and initial signal processing hardware was completed within budget for the Molonglo upgrade, one key element of the project, the correlator, didn't materialise within the scope of the budget. One of the unforeseen benefits of this delay was that since the project was first proposed, GPUs not only appeared but grew in power by over an order of magnitude.

By teaming up with Swinburne's Centre for Astrophysics and Supercomputing, engineers from CSIRO's Astronomy and Space Sciences (CASS) and staff from The University of Sydney have now designed the missing correlator that uses just 33 graphics cards housed in conventional servers. The total power draw is now less than 20 kW.

The first stage of this correlator has been deployed at the site, and 45 years after it was first discovered, the Vela pulsar was detected using just 0.3% of the telescope's power in 2013.

The project is now nearing completion. Data from the 352 receivers in the field will be sent via a custom board designed at The University of Sydney and currently being optimised by Timothy Bateman from CASS and Duncan Campbell-Wilson. When this task is completed the array will be used to search for Fast Radio Bursts, a phenomenon reported by CAASTRO staff and their international partners in *Science* in 2013.

The flexibility and power of the GPUs will enable "commensal" science to be performed by the correlator. In addition to searching for bursts the system will time hundreds of radio pulsars and be used to make maps of the Southern sky to contribute to all three of the CAASTRO themes: Dynamic, Evolving and Dark.

National Innovation Priority Case Study

INTERNATIONAL COLLABORATIONS

Dr Chris Lidman (Australian Astronomical Observatory)

It was through observations of distant Type Ia supernovae that we learned that the expansion of the Universe is not slowing down but actually speeding up. Subsequent follow-up studies combining the observations of hundreds of Type Ia Supernovae with the large scale pattern of clustering of galaxies and observations of the Cosmic Microwave Background have shown that, if Einstein's theory of gravity is correct, we live in a Universe that is dominated by dark energy. We know neither the physics that underpins dark energy nor the reason why it has the magnitude it has.

The Dark Energy Survey (DES) is a five year survey using DECam, a new wide-field imager on the 4m Blanco Telescope at CTIO[1]. The principle aim of DES is to increase our understanding of dark energy. DES consists of a wide survey that will image several thousand square degrees of the Southern Sky and a deep survey, consisting of 10 fields, targeting distant Type Ia Supernovae. DES started taking data at the end of August 2013.

In order to use Type Ia Supernovae to constrain dark energy, one needs to measure distances and redshifts[2]. Distances are inferred from the observed brightness of the Type Ia Supernovae, whereas redshifts have to be measured using a spectrograph.

DES will find thousands of supernovae. Obtaining redshifts for them one at a time, as was done in previous SN surveys, is not practical. Instead, by obtaining redshifts from galaxies that host the supernovae, we can obtain the redshifts of many supernovae at once.

The combination of the 2dF fibre positioner with its 392 fibres, and AAOmega is ideal for this kind of work. The field-of-view of the 2dF perfectly matches the field of view of DECam. However, most SN host galaxies are quite faint, meaning that long exposures with AAOmega are needed.

The strategy was tested in a pilot survey using host galaxies from the Supernova Legacy Survey. An article presenting some results from the pilot survey were presented in last year's annual report. Following the success of the pilot survey, we applied for time to use the AAT to target the 10 supernova fields of DES with 2dF and AAOmega over the next five years. Over 100 nights of telescope time have been allocated to the project, which is now called OzDES. Our first season of observations has just ended. We have already obtained the redshifts for hundreds of supernova host galaxies.

However, OzDES is more than just a supernova survey. At the same time as obtaining the redshifts of thousands of supernova hosts, we are monitoring AGN to measure black hole masses, we are classifying other transients - including a few live SNe, and we are obtaining redshifts for thousands of galaxies - including redshifts for sources in the ATLAS survey.

Innovation will be a key part of OzDES. As we'll be pushing 2dF and AAOmega harder than anyone has done in the past, we will need to develop new techniques to process and combine data from multiple AAOmega runs, and new ways to identify transients as soon as they are observed.

OzDES consists of 44 scientists from Australia and overseas. Nearly all the CAASTRO nodes are represented in OzDES. It is tied to the much larger DES collaboration through a number of agreements with the DES working groups. Over time, we hope to broaden our relationship with DES.

1 Cerro Tololo Inter-American Observatory

2 The redshift quantifies how much the size of the Universe has changed between the time the SN Ia actually exploded to when we observe it.

CAASTRO ebook on Mentoring

Clive Scollay with Maruku Artists Judy Okai, Jeska Matteson and Renita Armstrong
Credit: Kim Dorrell

National Innovation Priority Case Study

DEVELOPING A STRONG BASE OF SKILLED RESEARCHERS

Ms Kate Gunn (University of Sydney)

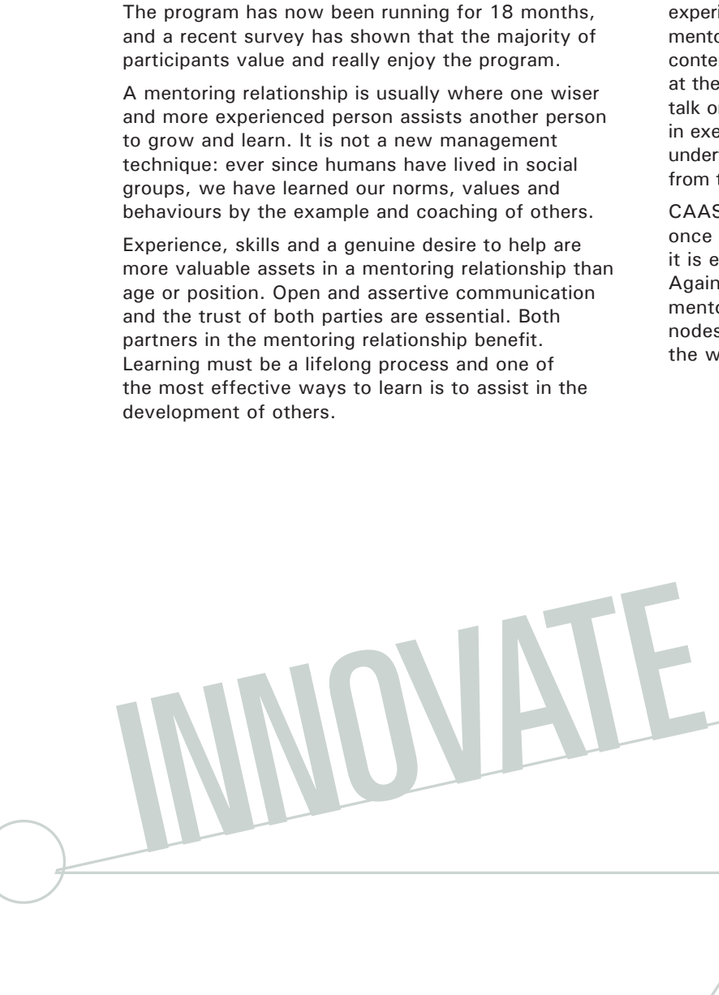
The CAASTRO Mentoring program was launched in August 2012, and almost every member of CAASTRO is either a mentor, a mentee or both. The program has now been running for 18 months, and a recent survey has shown that the majority of participants value and really enjoy the program.

A mentoring relationship is usually where one wiser and more experienced person assists another person to grow and learn. It is not a new management technique: ever since humans have lived in social groups, we have learned our norms, values and behaviours by the example and coaching of others.

Experience, skills and a genuine desire to help are more valuable assets in a mentoring relationship than age or position. Open and assertive communication and the trust of both parties are essential. Both partners in the mentoring relationship benefit. Learning must be a lifelong process and one of the most effective ways to learn is to assist in the development of others.

CAASTRO has developed a Mentoring e-book to assist mentors and mentees with the mentoring process. This innovative approach allowed us to train both experienced and inexperienced mentors. Experienced mentors can read the checklists and speed read the content, and less experienced mentors are able to learn at their own pace listening to CAASTRO members talk on the benefits of mentoring, and can participate in exercises to build their skills. Mentees in turn can undertake training in order to know what to expect from their mentoring relationship.

CAASTRO mentors and mentees should meet at least once a year face-to-face (at the Annual Retreat if it is easiest) and twice a year by video conference. Again our innovative use of technology has enabled mentors and mentees to be located in different nodes, and for knowledge transfer to occur across the whole of the country, and even internationally.



National Innovation Priority Case Study

COLLABORATION WITH BUSINESS

Ms Kate Gunn (University of Sydney)

In March 2013 CAASTRO visited Uluru for the first time as we prepared to hold our first Annual Science Retreat at the Voyages Ayers Rock Resort. As part of this preparation we met with the Conference team regarding our event, but we also met with the Management of Voyages to discuss possible collaboration between our organisations. The General Manager, Mr Ray Stone, based in Sydney, was a key driver in building this relationship as he had a vision for what the collaboration between our organisations could look like.

For CAASTRO this was a wonderful opportunity to engage with Industry in a remote part of Australia, as well as to enhance our Outreach program. For Voyages it was an opportunity to engage with a number of Australian Universities, facilitate knowledge transfer in relation to their Astronomy Tourism products, and provide a succession planning network for their Sky Talkers into the future. Over time we have found that together we are creating new tourism products that are benefiting both organisations.

The CAASTRO Science Conference, “Reionisation in the Red Centre: New windows on the high redshift Universe”, was held in July and was a great success. As part of this conference, Professor Steven Tingay provided an “Indigenous Australian Astronomy Public Talk” and this was attended by a large group of Indigenous Trainees who work for Voyages at the resort. Steven has a wealth of experience in Indigenous engagement through his work on the MWA. All parties recognised that this talk, and other discussions, was just the start of our journey of engagement, which we hope will continue for a number of years.

Working with Clive Scollay from Maruku Arts, a company situated in the Mutitjulu community, owned and controlled by the Anangu (Aboriginal people from the southeast and west of Central Australia), CAASTRO took the opportunity to create our own dot painting for our logo. All CAASTRO members at the Conference at Uluru participated, and we now have the painting proudly displayed on our Seminar Room wall in Sydney.

The eighteen Aboriginal communities serviced by Maruku extend as far west to Warburton, north to Warrakurna, Karrku and Tjukurla in Western Australia (part of the Tjulyuru cutltural centre in the Shire of Ngaanyatjarraku), east to the Finke River in the Northern Territory and south to Mimili, Indulkana and Fregon in South Australia as well as clusters of communities across both states and the territory closer to Uluru. There are approximately 800 Anangu members that make up the artists’ co-operative that is Maruku.

The collaboration that we have undertaken with Voyages in 2013 is the foundation for our activities moving into 2014. Activities currently being implemented in 2014 are our new “Astronomer in Residence” program at Uluru, and an Astronomy Weekend as part of National Science Week to be held in August 2014.

ACTIVITY PLAN FOR 2014

CAASTRO expects to have another enriching and rewarding 12 months with many stimulating activities and research discoveries.

CAASTRO RESEARCH PROGRAM

Dark Theme

There's an exciting year ahead for the CAASTRO Dark Theme, as some of our major projects are nearing completion. 2014 should see the final WiggleZ cosmology papers released, with a new baryon acoustic oscillation (BAO) measurement using reconstruction led by Eyal Kazin, and a joint analysis of our data with the Baryon Oscillation Spectroscopic Survey (BOSS), which is an overseas successor of WiggleZ. As part of this effort, substantial progress has been made on simulations and theoretical modelling. Jun Koda will publish his COLA simulations, which provide multiple realisations of a realistic universe much more efficiently than full numerical simulations could. These types of simulations are essential for calculating the uncertainty on our results and checking for biases, since we can't go out and repeat our measurements on multiple universes.

Meanwhile our peculiar velocity work is really gaining speed. Chris Springob will be publishing the 6dFGS velocity survey data, which Morag Scrimgeour and Andrew Johnson are both using for velocity analyses, with Morag releasing a bulk flow measurement, and Andrew presenting higher-order correlations — a velocity power spectrum similar to the density power spectrum we use for galaxy redshift surveys. The 2MTF team will also be releasing a bulk flow measurement led by Tao Hong, and are also expected to demonstrate a new way to calibrate the Tully-Fisher relation led by David Lagattuta. Looking to the future, Jun Koda will be publishing a substantial new effort showing how we can use TAIPAN/Wallaby data to constrain cosmology. His paper presents a new technique by which to combine multiple types of data, and predicts how accurately these surveys will be able to perform this combination.

Our supernova studies now have exciting new data coming in from two sources. SkyMapper is now discovering supernovae routinely, and in 2014 we expect to discover at least 50 good, pre-maximum nearby type Ia supernovae with well-sampled light-curves that are useful for cosmology, thanks to the fantastic efforts of our members such as Richard Scalzo, Fang Yuan, and Michael Childress. At the same time OzDES has just finished its first season of observing, and already has the largest sample of type Ia supernovae from any single telescope. 2014 will see our second OzDES observing season, and we will concentrate on streamlining our systems and ensuring the quality and reliability of our results in anticipation of the first cosmology papers.

Studies of dark matter and dark energy rely strongly on simulations, and our simulators will be hard at work over 2014 on large simulations in non-standard gravities, as well as hydrodynamic simulations in normal gravity. Discrepancies between simulations and observations on galaxy scales are significant, but there are indications that this may be because the simulations have not adequately captured the complex hydrodynamic interactions of the gas and dust in the galaxies. Alan Duffy will create a series of high-resolution hydrodynamic simulations of the first galaxies forming, tracking their ability to reionise the early Universe and checking the impact that complex gas dynamics and supernova feedback have on the dark matter properties of Milky Way progenitors. Meanwhile Steven Murray will be studying the covariances between cosmological parameters and the halo-occupation distribution parameters used to fill dark matter simulations with galaxies.

And finally, looking at possible explanations of dark energy and dark matter, David Parkinson will publish research on Galileon models of modified gravity, and use measurements of WiggleZ to constrain the models; Jason Dossett and others are initiating a suite of simulations that will study structure formation in non-standard models of gravity; and Katie Mack is leading an effort in collaboration with the particle physics centre of excellence CoEPP to calculate the effect dark matter particle annihilation would have on baryonic halos, and predict the observational effects for high-redshift 21cm and galaxy surveys.

Evolving Theme

2014 promises to be a very exciting year for science in the evolving theme, with several significant surveys reaching full operation. The SAMI Galaxy Survey will be in full flow, with data being collected for over 50 nights on the telescope. An early data release is planned for mid 2014 to give the astronomical community a taste of the richness of SAMI data. Key science projects currently in progress will be published in 2014, including studies into the role of the environment in quenching star formation, examination of the distribution of galaxies with high and low angular momentum, analysis of the role of winds in galaxies and many more.

2014 will see a further 350 hours of observing on the MWA Epoch of Reionisation (EoR) survey completed with 467TB of data collected. The MWA EoR collaboration is developing 3 independent and parallel data reduction pipelines, 2 for the targeted EoR fields and 1 for driftscan observations. CAASTRO researchers are leading pipeline development based around the MWA Realtime System, which is now operational and will be applied to the MWA EoR survey.

On the theoretical side, CAASTRO will continue the systematic super-computer simulation of the important processes in galaxy formation. During 2013 we published papers investigating the important effects shaping the mass and luminosity functions of galaxies during the epoch of reionisation. During 2014, 1.5M CPU hours will be invested to extend the suite of CAASTRO simulations to later cosmic times to discover the important physical processes during the peak era of galaxy formation.

Dynamic Theme

The Dynamic Theme is well positioned to consolidate some exciting research in 2014.

The new year will see a continuation of the MWA slow transients survey. This blind survey, using data taken from MWA observations that are being conducted in the Epoch of Reionisation fields as well as other fields, is targeting slow transient events on time scales from seconds to weeks. With its large instantaneous field of view and high sensitivity, MWA is well-suited for such a blind survey.

MWA will also be used to search for fast radio bursts. With durations of only a few milliseconds, fast radio bursts are a recently discovered phenomenon whose origins are unclear. Recently published research by CAASTRO's Cathryn Trott, Steven Tingay and Randall Wayth suggests that the MWA will be able to detect several fast radio bursts per month.

The Molonglo Radio Telescope near Canberra is being upgraded into the Square Kilometre Array Molonglo Pathfinder (SKAMP) by The University of Sydney, CSIRO and Swinburne University of Technology. Molonglo's wide field of view will make it well-equipped for detecting fast radio bursts and characterising them, giving us new insight into their origins. At the same time, Molonglo will also be engaged in the continual monitoring of many pulsars (at the same time as searching for transients) and will have the ability to perform timing analysis on all pulsars in the field of view simultaneously.

Education & Outreach

In 2014, CAASTRO will continue a strong social media presence, will maintain our regular outreach programs such as “CAASTRO in the Classroom” (Sydney) and “Pint in the Sky” (Melbourne/Perth), and will support our partnerships with “Telescopes in Schools” and Quantum Victoria. As in previous years, CAASTRO will participate in “Astrofest” (Perth), offer a professional development workshop for our students and junior research staff (Brisbane), and organise a National Science Week activity with Mount Burnett Observatory (Melbourne).

In addition to these activities, this year will see some new products in the outreach portfolio. The new collaboration with “Voyages Indigenous Tourism Australia” will involve some of our Chief Investigators attending and presenting at an astronomy weekend at Uluru. We will also launch our “Astronomer in Residence” Program at Uluru in 2014. We will intensify our collaborations with Swinburne Astronomy Productions to create an extensive library of animations of CAASTRO research areas, and will begin working with Museum Victoria on a planetarium show. We are looking forward to exciting times ahead for CAASTRO Education & Outreach.

Gender Action Committee

In 2014 CAASTRO is establishing a Gender Action Committee. This Committee will identify and help set up programs with the aim to improve gender representation in the centre, and to enhance the long term career opportunities for women who are members of the centre.

Commercialisation and Knowledge Transfer

There is a trend for OECD economies to move towards high technology industries with more highly skilled labour and associated productivity gains. Australia is very committed to this, and CAASTRO is well placed to add value through industry engagement and knowledge transfer.

Whilst there have been some truly notable spin-outs to industry in the long history of radio astronomy, these are rare events. In 2013 we held an IP brainstorming session at the CAASTRO Annual Retreat, and in 2014 we will continue to look for these rare events. The Astronomy industry experience has had greater success with the engagement of smaller companies in the development of telescopes and hardware. Given CAASTRO’s primary focus on pure research, we approach commercialisation and knowledge transfer in innovative ways.

In 2014 CAASTRO will develop an e-book to educate and assist researchers in identifying and protecting intellectual property, industry engagement, and assisting with knowledge transfer. 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 2014 CAASTRO will continue to provide leadership in this area.

MWA
Credit: Emil Lenc

2013 PUBLICATIONS

Refereed Scientific Publications

Includes all CAASTRO papers published or accepted for publication in 2013

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STUDENT LIFE

Emily Petroff

CAASTRO PHD STUDENT,
SWINBURNE UNIVERSITY OF TECHNOLOGY

I am a PhD candidate at the Centre for Astrophysics and Supercomputing at Swinburne University of Technology, jointly supervised at CSIRO Astronomy and Space Science (CASS). I work with Willem van Straten, and Matthew Bailes at Swinburne, and Simon Johnston at CASS, studying pulsars and radio transients.

I completed my undergraduate degree in Physics at Carleton College in the United States where I began my pulsar career working with Joel Weisberg and collaborating with scientists in Australia. My first visit to Australia for astronomy was in 2009 when I worked at CASS on pulsar timing and radio observations with the Parkes Telescope. I was hooked after they let me drive the telescope!

Since moving to Melbourne I have become heavily involved in the transition to remote observations at Parkes and the High Time Resolution Universe (HTRU) survey conducted there. My PhD work thus far has focused on searches for radio transients in over 190 TB of survey data. The HTRU survey, the biggest pulsar survey ever conducted at Parkes, is only just being processed for the first time and is beginning to open up the population parameter space for time-variable objects in our Galaxy and beyond. My main goal is to analyse thousands of observations near the Galactic plane to identify a population of sporadically emitting pulsars. I am also searching for fast radio bursts, a new class of bright, millisecond-duration radio bursts thought to originate at cosmological distances. I use these observations to probe the interstellar medium of the Galaxy and learn more about pulsars in general. It's exciting stuff!

I joined CAASTRO in 2012 at the beginning of my PhD and had the chance to attend some wonderful events. As part of the Dynamic Theme I have been able to travel to the telescope for my observations as well as overseas to meet collaborators and speak about my research.

Tao Hong

CAASTRO PHD STUDENT,
ICRAR | UNIVERSITY OF WESTERN AUSTRALIA

I am a PhD student at the National Astronomical Observatories, Chinese Academy of Sciences. I completed my undergraduate degree at Nanjing University in June 2009; shortly after that I moved to Beijing and started my 5-year PhD in astrophysics. In 2010, I met Lister Staveley-Smith (ICRAR/University of Western Australia), who is now my joint supervisor. In 2011 I joined CAASTRO. As a joint supervised student, I currently spend half of my time in Western Australia, and the rest of my time in China.

Under the CAASTRO Dark theme, I'm working on the 2MASS Tully-Fisher Survey with Lister Staveley-Smith and Chris Springob (ICRAR/University of Western Australia). After measuring redshift independent distances and peculiar velocities for approximately 2,500 local spiral galaxies, I am using this dataset to analyse the peculiar velocity field, and am trying to improve our understanding of the matter distribution and large-scale structure in the local Universe.

Eromanga Adermann

CAASTRO HONOURS STUDENT,
THE UNIVERSITY OF SYDNEY

I completed my BSc (Hons) degree in physics at the University of Sydney in 2013. I worked with Sean Farrell and Anne Green on the characterisation of ultra-luminous X-ray sources (ULXs), which are extra-galactic non-nuclear point sources with X-ray luminosities in excess of the Eddington limit for a 10 solar mass black hole. ULXs are believed to be either stellar mass black holes accreting at super-Eddington rates or active intermediate mass black holes.

The aim of my Honours work was to determine how the population of ULXs breaks down into stellar mass black holes accreting in super-Eddington regimes and intermediate mass black holes. I searched for ULXs in galaxy environments where extreme accretion onto stellar mass black holes is unlikely, and found at least one intermediate mass black hole candidate. I also utilised the Random Forest machine learning algorithm to compile a reliable ULX catalogue, which I subsequently used to perform a population study of ULXs. The results of my study suggest that most ULXs consist of stellar mass black holes accreting at super-Eddington rates. However, the possibility that intermediate mass black holes comprise a significant sub-group of the ULX population remains open.

Catherine De Burgh-Day

CAASTRO PHD STUDENT,
UNIVERSITY OF MELBOURNE

I am a third year PhD student at the University of Melbourne, supervised by Professor Rachel Webster, Dr Edward Taylor and Associate Professor Andrew Hopkins at the AAO. I joined CAASTRO in early 2012, at the beginning of my PhD.

For my PhD I am developing a new technique called Direct Shear Mapping (DSM) to directly measure weak gravitational lensing signals in individual galaxies using spatially resolved spectroscopy. I expect this technique to allow us to make novel measurements of weak lensing shear in galaxies, lensed by both clusters and other field galaxies. I began my work on DSM during my MSc., also working with Professor Rachel Webster. During my Masters I performed a feasibility study, investigating the possibility of making shear measurements with 3D data. It turned out to be feasible, and I was so interested and excited in the possibilities the technique offered that I decided to make developing it the focus of my PhD.

Currently I am investigating the probability of making weak galaxy-galaxy lensing detections at low to intermediate redshift, and investigating the distribution of possible shears present in the galaxies in the Galaxy and Mass Assembly (GAMA) survey. I am planning to use what I learn from the galaxies in the GAMA catalogue to help me select several galaxies on which to obtain IFU data. I hope to make a direct measurement of shear in these galaxies and use it to measure properties of their dark matter halos.

2013 CAASTRO Students

2013 CAASTRO Post Doctoral Researchers

2013 NEW CAASTRO STUDENTS

University of Sydney

Eromanga Adermann, *Evolving, Honours*
SUPERVISORS Sean Farrell, Anne Green
THESIS TITLE A Population Study of Ultra-Luminous X-Ray Sources

Jessica Bloom, *Evolving/Dark, PhD*
SUPERVISORS Joss Bland-Hawthorn, Scott Croom, Lisa Fogarty
THESIS TITLE Dynamical Interactions in Nearby Galaxies

Joseph Callingham, *Evolving, PhD*
SUPERVISORS Bryan Gaensler, Sean Farrell, Randall Wayth, Ron Ekers
THESIS TITLE An MWA Source Catalogue: Compact Steep Spectrum and Gigahertz Peaked Spectrum Sources at Low Radio Frequencies

Marcin Glowacki, *Evolving, Honours*
SUPERVISORS Stephen Curran, James Allison
THESIS TITLE Quasar Ionisation of the Star-Forming Gas in Galaxies

Fabian Jankowski, *Dynamic, PhD*
SUPERVISORS Matthew Bailes, Willem van Straten
THESIS TITLE The Radio Universe at 1000 times frames per second

Sarah Leslie, *Evolving, Pre-PhD*
SUPERVISORS Elaine Sadler, Scott Croom
PROJECT TITLE A radio continuum study of SAMI galaxies

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

Samuel Richards, *Evolving, PhD*
SUPERVISORS Joss Bland-Hawthorn, Julia Bryant
THESIS TITLE Novel new astrophotonic technologies and telescope instruments to address the role of star formation as a function of galaxy environment.

Adam Schaefer, *Evolving, PhD*
SUPERVISORS Scott Croom, James Allen
THESIS TITLE The modulation of star formation by galaxy environment using the Sydney-AAO Multi-object Integral Field Spectrograph (SAMI)

University of Melbourne

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

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

Australian National University

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

ICRAR | Curtin University

Hannah Feldman, *Outreach, Honours*
SUPERVISORS Wiebke Ebeling, Steven Tingay
THESIS TITLE Development of Astronomy School Activities using the MWA

Cody Gough, *Dynamic, Honours*
SUPERVISORS Ramesh Bhat, Matthew Bailes
THESIS TITLE Binary-Pulsar Timing with the CASPSR Baseband Recorder at Parkes

Luke Horsley, *Evolving, Honours*
SUPERVISORS Natasha Hurley-Walker, Steven Tingay
THESIS TITLE Characterising the ionosphere using the Murchison Widefield Array

Jarrod Ramsdale, *Dynamic/Evolving, Honours*
SUPERVISORS Jean-Pierre Macquart
THESIS TITLE Imaging extremely bright emission from relativistic jets using the IS telescope

Kimberly Steele, *Evolving, Honours*
SUPERVISORS Randall Wayth, Elaine Sadler
THESIS TITLE HI absorption in the high redshift quasar 0924-2201

ICRAR | University of Western Australia

Scott Meyer, *Evolving/Dark, PhD*
SUPERVISORS Martin Meyer, Danail Obreschkow
THESIS TITLE Investigating the Tully-Fisher relation and galaxy kinematics through neutral Hydrogen spectral line stacking techniques

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

Cardiff University, UK

Jake Hughes, *Dynamic/Evolving, Pre-PhD*
SUPERVISORS Anne Offringa, Frank Briggs
PROJECT TITLE Analysing Sources of Radio-Frequency Interference for the MWA

CONTINUING CAASTRO STUDENTS

University of Sydney

Kitty Lo *Dynamic, PhD*
SUPERVISORS Bryan Gaensler, Tara Murphy
THESIS TITLE Exploring the radio transient sky

Glen Rees *Evolving, Pre PhD*
SUPERVISORS Scott Croom, Ray Norris
PROJECT TITLE Analysing sub-detection source distributions

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

Bradley Greig *Dark, PhD*
SUPERVISORS Stuart Wyithe, Jamie Bolton
THESIS TITLE Lyman Alpha Forest and Lyman alpha emitters as cosmological probes of dark energy

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

Christina Magoulas *Evolving, PhD*
SUPERVISORS Rachel Webster, Jeremy Mould, Matthew Colless
THESIS TITLE Properties of Galaxies from the 6dF Galaxy Survey

Sinem Ozbilgen *Dark, MSc*
SUPERVISORS Rachel Webster, Jeremy Mould
THESIS TITLE Calibrating the Tully-Fisher Relationship

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

Jennifer 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

Syed Faisal-Ur-Rahman *Dark, Pre-PhD*
SUPERVISOR Brian Schmidt
PROJECT TITLE Integrated Sachs Wolfe Effect

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*
SUPERVISOR Brian Schmidt
THESIS TITLE Gamma Ray Bursts and Exploding Stars

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

Ragini Singh *Evolving, PhD*
SUPERVISOR Brian Schmidt
THESIS TITLE Quasars and the Transverse Proximity Effect

ICRAR | Curtin University

Mehran Mossammaparast *Evolving, MSC*
SUPERVISORS Steven Tingay, Randall Waythe, Peter Hall at ICRAR, Curtin.
THESIS TITLE Radiometric Receiver for Measuring Red-shifted 21cm 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

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

Morag Scrimgeour *Dark, PhD*
SUPERVISORS Lister Staveley-Smith, Peter Quinn, Tamara Davis
THESIS TITLE Measuring Cosmology with Motion in the Universe

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

CAASTRO GOVERNANCE

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 six 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 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 monthly via video-conference, and quarterly at a face-to-face meeting. 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 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 Bryan Gaensler
Research Director

Professor Lister Staveley-Smith
Deputy Director

Ms Kate Gunn
Chief Operating Officer

During 2013 the University of Queensland was added as a Node to CAASTRO and late in 2013 we welcomed Associate Professor Tamara Davis to the CAASTRO Executive.

In 2013, the CAASTRO Executive met 10 times, including face-to-face meetings at Swinburne, University of Sydney, ICRAR University of Western Australia, ICRAR Curtin University and at the Australian National University. During 2013, area meetings were held in Sydney, Canberra, Melbourne and Perth. All the CAASTRO Collaboration Partners have signed a Collaboration Agreement which sets out the way the research partnership will operate. In addition a CAASTRO Multi-Institute Agreement (MIA) has been signed by all the CAASTRO Partners.

In 2013, CAASTRO's first Theme Scientists finished their terms after a 20 month period, and have gained leadership experience and new skills during this time. Thanks must go to Dr Emil Lenc (Evolving), Dr Steven Tremblay (Dynamic) and Dr Chris Springob (Dark) for their hard work as CAASTRO Theme Scientists in 2013. Their assistance in putting together the Research Project Plans and organising Theme Meetings has been invaluable.

The following diagram shows the CAASTRO Governance structure:

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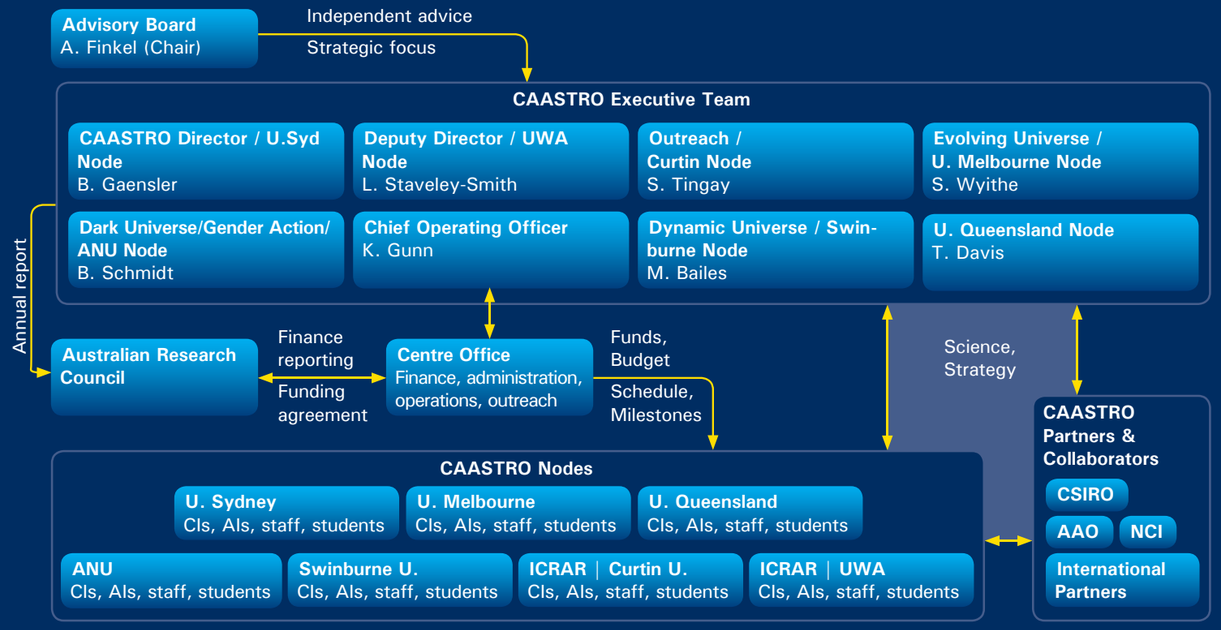


CAASTRO Advisory Board

The CAASTRO Advisory Board met three times in 2013, including a two day planning meeting held in Perth in November. The Board has considered matters of strategy, responding to the changing external environment, the Centre research program, collaboration across distances, community outreach, intellectual property and industry engagement. They have also met with our students, researchers and professional staff.

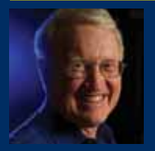
CHAIR
Dr Alan Finkel AM
Chancellor
Monash University

MEMBER
Ms Soula Bennett
Director
Quantum Victoria

MEMBER
Mr Geoffrey Burchfield
Director
National Youth Science Forum
(January – October 2013)

MEMBER
Prof Bryan Gaensler
CAASTRO Director

MEMBER
Prof Martha Haynes
Goldwin Smith Professor of Astronomy
Cornell University



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

MEMBER
Prof Tanya Monro
Director
Institute for Photonics & Advanced Sensing
University of Adelaide

MEMBER
Mr Guy Robinson
Systems Architect
Pawsey Supercomputing Centre, CSIRO

MEMBER
Prof Alistar Robertson
Emeritus Professor/
Senior Honorary Research Fellow, UWA

MEMBER
Prof Kenneth Freeman
Duffield Professor of Astronomy, Australian National University

MEMBER
Prof Ron Ekers
CSIRO Fellow

CAASTRO Executive

(Left to right) Steven Tingay, Brian Schmidt, Bryan Gaensler, Matthew Bailes, Kate Gunn, Stuart Wyithe, Tamara Davis and Lister Staveley-Smith

CAASTRO MEMBERSHIP

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 Astrophysics	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

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 legal obligations that the Administering Organisation has with the ARC.
- Accept the intellectual property policy of CAASTRO.
- Accept that all disputes regarding membership will be referred to the Research Director.
- Accept that membership is not transferable between individuals.

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 funded from a Collaborating Organisation, Partner Organisation or other source, and who are participating in CAASTRO research projects with specific deliverables. Associate Investigators are responsible for making an intellectual and strategic contribution to CAASTRO in their specific area(s) of expertise. 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. All 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., Super Science Fellows working alongside CAASTRO researchers at CAASTRO nodes), or 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 students or honours 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.

AWARDS & HONOURS

External recognition for the CAASTRO team continued in 2013, with a number of team members receiving awards and honours for their achievements.

Chris Blake received the 2013 Pawsey Medal for research in physics from the Australian Academy of Science. The Pawsey Medal recognises the outstanding research in physics by early-mid career scientists.

Bryan Gaensler, the CAASTRO Director, was elected as a Fellow of the Australian Academy of Science. The Australian Academy of Science annually honours a small number of Australian scientists for their outstanding contributions to science by electing them as Fellows of the Academy. Bryan was made a Fellow in recognition of his fundamental contributions to our understanding of the Universe through his outstanding research on high-energy astrophysics, cosmic magnetic fields and the structure of our Galaxy.

Bryan Gaensler also won the 2013 Scopus Young Researcher Award for the Physical Sciences. The award and prize money from Elsevier was presented to Bryan on 13 September at the Scopus Young Researcher Award lunch, at the Australian Research Management Society conference, in Adelaide.

Rachel Webster has been awarded the 2013 Robert Ellery Lectureship. The Lectureship recognises outstanding research relating to southern hemisphere astronomy. Rachel has been influential in astronomy for more than two decades and has been the driving force behind the HI Parkes All Sky Survey (HIPASS) and the Murchison Widefield Array (MWA).

Steven Tingay, CAASTRO Education and Outreach Leader, was awarded the Curtin University's Vice-Chancellor Award for Excellence & Innovation in Research Development (the Paul G Dunn prize). Steven has been instrumental in constructing and launching the Murchison Widefield Array (MWA). The Murchison Widefield Array (MWA) is a low-frequency radio telescope operating between 80 and 300 MHz. It is located at the Murchison Radio-astronomy Observatory (MRO) in Western Australia, the planned site of the future Square Kilometre Array (SKA) low band telescope, and is one of three telescopes designated as a Precursor for the SKA. The MWA has been developed by an international collaboration, including partners from Australia, India, New Zealand, and the United States

Steven Tingay was also a finalist in the WA Scientist of the Year in 2013. The WA Science Awards are held by the Department of the Premier and Cabinet's Office of Science and are designed to recognise and celebrate the achievements of Western Australia's science community.

Brian Schmidt was made a Companion of the Order of Australia in the 2013 Honours List.

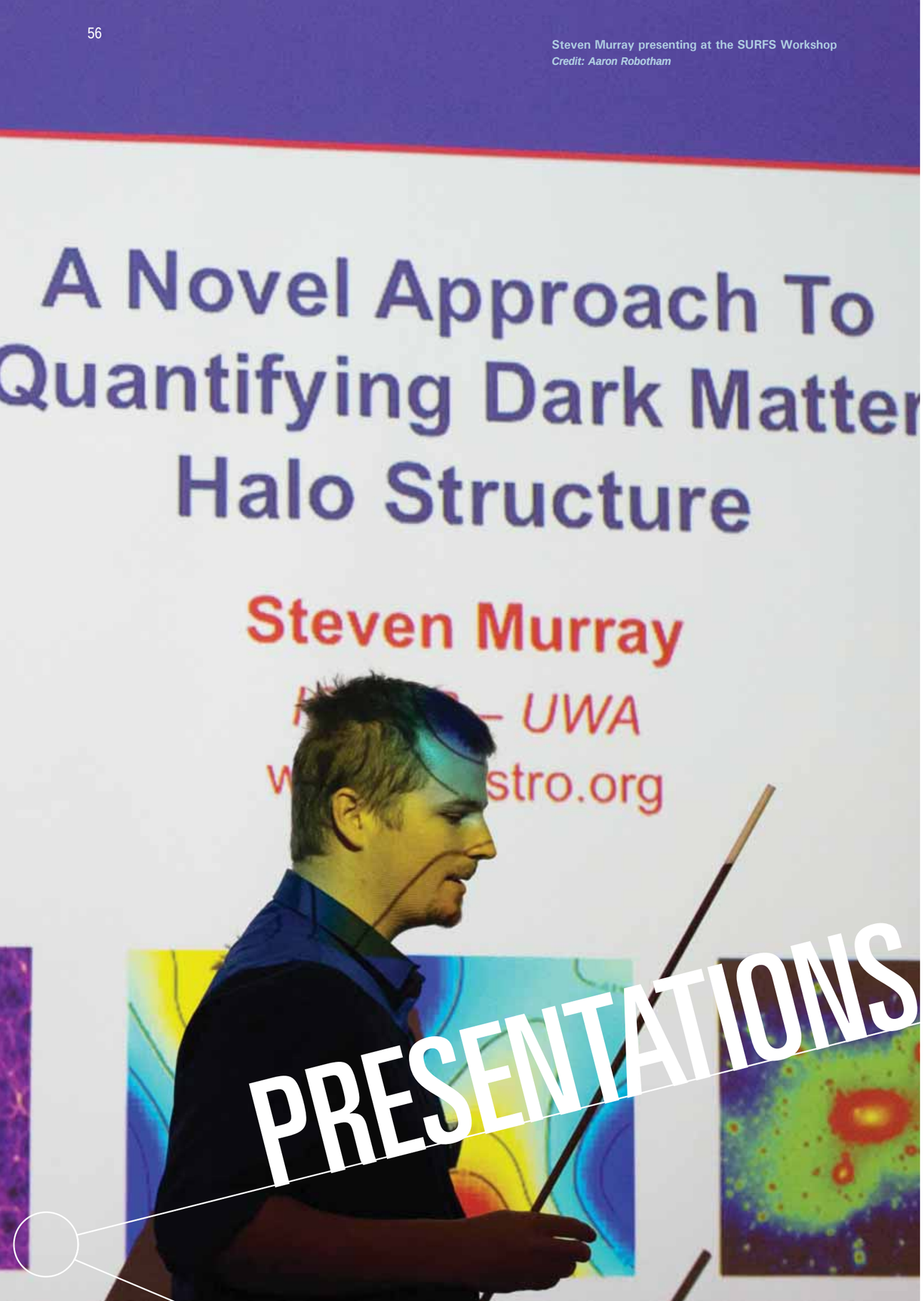
Dr Brian Boyle received a Public Service Medal in the 2013 honours list

Bryan Gaensler at the Australian Academy of Science.
Credit: Mark Graham

Steven Tingay at Curtin University.
Credit: Marisa Wikramanayake, Curtin University

Chris Blake at the Australian Academy of Science.
Credit: Warrick Couch.

Rachel Webster.
Credit: University of Melbourne



Steven Murray presenting at the SURFS Workshop
Credit: Aaron Robotham

PRESENTATIONS

INVITED TALKS 2013

Major Conferences

**this list does not include public talks or school talks*

Radio observations of SN 1987A
Lister Staveley-Smith, International Astronomical Union Symposium 296, India, January 2013

Fundamentals of Radio Astronomy
Matthew Bailes, High Performance Computing Workshop on Signal Processing, South Africa, January 2013

Pulsar instrumentation, now and in the future
Matthew Bailes, Physical Applications of Millisecond Pulsars, USA, January 2013

How to use Astronomy as a development driver
Brian Schmidt, Chilean National Congress: World's Future and Frontiers of Science, Technology, Humanities and Citizenship, Chile, January 2013

Supernovae and dark energy
Brian Schmidt, Cosmology, Large Scale Structure and First Objects, Brazil, February 2013

The SAMI Galaxy survey
Scott Croom, Dissecting galaxies with 2D wide-field spectroscopy, China, March 2013

HI cosmology
Martin Meyer, Modern Radio Universe, Germany, April 2013

Transient science with SkyMapper and the next generation of ground-based surveys
Fang Yuan, The 2nd PANDA Symposium on Multi-messenger Astronomy, China, April 2013

Statistical studies of supernovae from wide field optical surveys
Fang Yuan, 2013 International Collaboration Meeting on Antarctic Survey Telescopes, China, May 2013

The Murchison Wide-field Arrray and the transient and variable radio sky
Martin Bell, Locating Astrophysical Transients, Lorentz Centre, The Netherlands, May 2013

Locating astrophysical transients
Steven Tingay, Locating Astrophysical Transients, Lorentz Centre, The Netherlands, May 2013

The VAST survey
Paul Hancock, iVOA Interop Meeting, Germany, May 2013

Reionisation and galaxy formation during the first Billion years
Stuart Wyithe, Cosmic Dawn at Ringberg, Germany, June 2013

MWA EOR experiment
Bart Pindor, 21cm Cosmology, National Astronomical Observatories, Chinese Academy of Sciences (NAOC), China, July 2013

Transients and Variables with the MWA
Martin Bell, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

SAMI and the SAMI Galaxy survey
Julia Bryant, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

The giant lobes of Centaurus A observed with the Murchison Widefield Array
Ben McKinley, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Do we have robust astrophysical tests of dark matter?
Chris Power, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Science with SKA1 – survey
Lister Staveley-Smith, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

What can a gravitationally-lensed quasar teach us?
Rachel Webster, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Science with SKA1 - Low frequency
Stuart Wyithe, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

The MWA all-sky survey
Randall Wayth, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Information and the MWA: Understanding information flow to deliver precision science
Cathryn Trott, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

The SNIa Hubble diagram
Brian Schmidt, Ripples in the Cosmos, UK, July 2013

Cosmology with the WiggleZ survey and beyond
Chris Blake, Ripples in the Cosmos, UK, July 2013

Young radio galaxies in the local universe
Elaine Sadler, The Triggering Mechanisms for Active Galactic Nuclei, The Netherlands, July 2013

What are we missing in E galaxies?
Jeremy Mould, Tropical CoEPP meeting, Australia, July 2013

Complete ionisation of the neutral gas in high redshift active galaxies
Steve Curran, Modern Radio Universe, Germany, April 2013; Synergistic Science with Euclid and the SKA, UK, August 2013

Murchison Widefield Array - An SKA Precursor
Rachel Webster, 2013 Asia Pacific Radio Science Conference, Taiwan, September 2013

SKA Science and Technology
Lister Staveley-Smith, 2013 Asia Pacific Radio Science Conference, Taiwan, September 2013

Students in transition - the learner's journey
Brian Schmidt, Conference on Science and Mathematics Education, ACSME, Australia, September 2013

Two populations of GRB radio afterglows
Paul Hancock, Explosive Transients: Lighthouses of the Universe, Greece, September 2013

The AT20G view of Swift/BAT AGN: HE X-rays meet radio waves
Davide Burlon, Explosive Transients: Lighthouses of the Universe, Greece, September 2013

A population of fast radio bursts at cosmological distances
Matthew Bailes, Explosive Transients: Lighthouses of the Universe, Greece, September 2013

Discovering the unexpected in large surveys
Brian Schmidt, Astroinformatics Conference Knowledge from Data, Australia, November 2013

Astroinformatics challenges for next generation radio transients surveys
Tara Murphy, Astroinformatics Conference Knowledge from Data, Australia, November 2013

Wide-field radio astronomy and the dynamic universe
Bryan Gaensler, Black Holes, Jets and Outflows, Nepal, November 2013

Applications of astrophotonics to astronomy in Antarctica
Julia Bryant, China-Australia Symposium, China, November 2013

A New Way of Looking at the Sky: Radio Astronomy in the Wide-Field Era
Bryan Gaensler, China-Australia Symposium, China, November 2013

Exploring the transient radio sky with ASKAP and the MWA
Tara Murphy, Ephemeral Universe Meeting, Australia, November 2013

Tripping the light fantastic with an intra-hour variable quasar
Jean-Pierre Macquart, Gerfest - The Radio Universe @ meter wavelengths, The Netherlands, November 2013

The SkyMapper Southern Sky Survey search for supernovae & transients
Richard Scalzo, Hotwiring the Transient Universe, USA, November 2013

The MWA GLEAM survey
Randall Wayth, Exploring the Radio Transient Sky, VAST Conference, Australia, December 2013

Extreme scattering events: detection, monitoring and new ISM physics
Jean-Pierre Macquart, Exploring the Radio Transient Sky, VAST Conference, Australia, December 2013

Source finding problems, progress, and prospects, for transient radio surveys
Paul Hancock, Exploring the Radio Transient Sky, VAST Conference, Australia, December 2013

Optical - radio transient synergies
Brian Schmidt, Exploring the Radio Transient Sky, VAST Conference, Australia, December 2013

The MWA radio sky monitor and VAST pipeline
Martin Bell, Exploring the Radio Transient Sky, VAST Conference, Australia, December 2013

Source finding for next generation radio transient and variable surveys
Paul Hancock, Exploring the Radio Transient Sky, VAST Conference, Australia, December 2013

A new low-frequency MWA Sky Survey
Lister Staveley-Smith, Meterwave Sky Conference, India, December 2013

Public Lectures 2013

Public Lecture, University of Cape Town, South Africa, Matthew Bailes, January 2013

Public Lecture, Aspen, USA, Matthew Bailes, January 2013

Curtin Indigenous Research Network (CIRN), "Ilgarijiri - Things Belonging to the Sky: Connecting Australian Indigenous Artists and Astrophysicists", Perth, Steven Tingay, March 2013

Public Lecture, "Understanding the Universe", Melbourne, Syed Uddin, March 2013

Lansdowne lecture at University of Victoria, "Everything from Nothing, or How Our Universe Was Made", Canada, Carlos Frenk, April 2013

Public Lecture, "How Big is the Universe", Melbourne, Eyal Kazin, May 2013

Leibniz Kolleg, Awards presentation lecture for students and postdoctoral researchers, Germany, Brian Schmidt, May 2013

Sydney City Sky Watchers, "Variables and Transients", Sydney, Paul Hancock, May 2013

Academy of Science, Launch of 31 Primary Connections, Canberra, Brian Schmidt, May 2013

Timor Leste, Science Education talks, East Timor, Brian Schmidt, May 2013

Engineers Australia book launch, "A Century of Canberra Engineering", Canberra, Brian Schmidt, May 2013

The Australia Institute, Science (Politics) in the Pub, "Using Evidence as a basis of Policy in Australia", Canberra, Brian Schmidt, May 2013

Royal NSW Society (RNSWS) 2013 Forum, "Maths and science education in Australia – is there a crisis?", Sydney, Brian Schmidt, June 2013

Australian Academy of Science, East Asia and Pacific Summer Institutes (EAPSI) Program, "Science in Australia', Canberra, Brian Schmidt, June 2013

Public Lecture, "Large Scale Galaxy Surveys", Sydney, James Allen, June 2013

Museum of Contemporary Art, MCA on the Rocks, "I'm looking through you - the gentle art of invisibility", Sydney, Brian Schmidt, June 2013

Public Lecture, "Why High Performance Computing is crucial to understanding how galaxies form", Perth, Chris Power, June 2013

Public Lecture, "Reinventing astronomy with radio telescopes: the Murchison Widefield Array, the Square Kilometre Array and Curtin", Perth, Steven Tingay, June 2013

Magnets in the sky
Bryan Gaensler, Leaders in Science & Medicine Seminar, Garvan Institute, Sydney, Australia, June 2013

Public Lecture, "Understanding the Universe", Melbourne, Syed Uddin, July 2013

University of Sydney, Sydney Ideas Series Public lecture, "Exploring the Universe", Sydney, Brian Schmidt, July 2013

Northern Sydney Astronomical Society, "First Stars in the Universe", Sydney, Brian Schmidt, July 2013

Introduction address for public lecture of Lawrence Krauss, Canberra, Brian Schmidt, July 2013

Young Presidents Organisation (Sydney) Education, "The Man Who Changed the Universe", Sydney, Brian Schmidt, July 2013

Public Lecture, Western Sydney Freethinkers, Sydney, Bryan Gaensler, August 2013

Australia Japan Foundation Workshop, "Journey to Winning a Nobel Prize", Australia, Brian Schmidt, August 2013

University of Western Australia, Talk and demonstration of radio astronomy, Perth, Chris Springob, August 2013

Launch of Illuminations Exhibition at NCSS, Australian Synchrotron, Melbourne, Brian Schmidt, August 2013

Public Lecture, Canberra Astronomical Society, Canberra, Brian Schmidt, August 2013

2013 South Australian Science Excellence Awards Gala Dinner, Keynote speech: "The Importance of Science in Australia:, Adelaide, Brian Schmidt, August 2013

The Indian Academy of Science talk - Institute of Science, "Type 1a Supernovae and the Accelerating Universe", India, Brian Schmidt, August 2013

Bangalore University, "The Accelerating Universe", India, Brian Schmidt, August 2013

University of Alaska, "Deliver the Freshman Convocation: Life the Universe and Everything", USA, Brian Schmidt, August 2013

Public Lecture, University of Alaska, "First Stars in the Universe", USA, Brian Schmidt, August 2013

Public Lecture, "Evolution of the Multiverse", Melbourne, Jeremy Mould, September 2013

Public Lectures, Stromlo Public Nights, Canberra, Brian Schmidt, September 2013

TEDxBrisbane, Brisbane, Tamara Davis, September 2013

Public Talk, Brisbane Square Library, Brisbane, Tamara Davis, September 2013

Public Lecture, Eminent Science 2013, Curtin University, Perth, Steven Tingay, September 2013

Panellist, Jewish Writers Festival, Sydney, Bryan Gaensler, September 2013

Science & Technology in Society Forum 2013, 'Why do we study the stars?', Japan, Brian Schmidt, October 2013

Public Lecture, "Identifying Type Ia Supernova Progenitors Using their Bolometric Light Curves", Perth, Richard Scalzo, October 2013

Siding Spring Observatory, Bok Lecture, Coonabarabran, Brian Schmidt, October 2013

Public Lecture, "Observing echoes of the Big Bang in the Universe's distant light", Melbourne, Chris Blake, October 2013

Public Lecture, Swinburne University, Melbourne, Chris Blake, October 2013

Public Lecture, "From Wifi to Aliens: Exploring the Dark Universe: What the Square Kilometre Array might mean for us", Melbourne, Brian Boyle, October 2013

Western Sydney Amateur Astronomy Group, "Fundamentals of radio astronomy", Sydney, Joseph Callingham, November 2013

Public Lecture, Mt Barnett Observatory AGM, to 30 amateur astronomers on Dark Matter, Melbourne, Alan Duffy, November 2013

Public Lecture, Astronomical Society of NSW, Sydney, Elaine Sadler, November 2013

International Council on Monuments and Sites, Australian National Conference 2013, "Imagined pasts… Imagined futures …", Canberra, Brian Schmidt, November 2013

Public Lecture, Swinburne University, Melbourne, Eyal Kazin, November 2013

Public Lecture and Panel, Swinburne University, "How to not manage your time", Melbourne, Rachel Webster, November 2013

Australian National University, "Reionisation and galaxy formation", Canberra, Stuart Wyithe, December 2013

LanewayLearning, "Dark Matter: Seeing The Invisible", Melbourne, Alan Duffy, December 2013

Allison-Levick Lecture, Canberra, Joss Bland-Hawthorne, December 2013

Other Presentations 2013

(Conferences. Workshops, colloquia, projects, collaborations)

Host Galaxies and Hubble Residuals of Type Ia Supernovae from the Nearby Supernova Factory
Mike Childress, 221st Meeting of the American Astronomical Society, USA, January 2013

ANGUS (AustraliaN GADGET-3 Ultimate Simulations): first results
Edoardo Tescari, 3rd HydroSim Meeting, Italy, January 2013

Supernova Environments
Mike Childress, Global Telescope (LCOGT), USA, January 2013

A Next Generation 2 micron sky survey
Jeremy Mould, Cooks Branch workshop, Kunlun Dark Universe Survey Telescope, USA, January 2013

Uncovering the transient Universe: from single-dish to multi-element instruments
Ramesh Bhat, National Centre for Radio Astrophysics (NCRA), India, January 2013

Exact & fast widefield imaging
Andre Offringa, 3rd Generation Calibration Workshop, South Africa, February 2013

100 million years after the Big Bang
Jeremy Mould, ANU colloquium, Mt Stromlo, Australia, February 2013

What we do well: Education & Outreach through the Use of Social Media
Wiebke Ebeling, ARC Centres of Excellence Professional Staff Day, Sydney, Australia, February 2013

Dark Matter Particle Physics in Cosmological Simulation
Katie Mack, Australian National Institute of Theoretical Astrophysics (ANITA) Annual Workshop, Brisbane, Australia, February 2013

Testing Galaxy Formation with Mass-scaling Relations
Alan Duffy, Australian National Institute of Theoretical Astrophysics (ANITA) Annual Workshop, Brisbane, Australia, February 2013

A framework for interpreting fast radio transients experiments
Cathryn Trott, Australian National Institute of Theoretical Astrophysics (ANITA) Annual Workshop, Brisbane, Australia, February 2013

Insights into Dark Matter
Katie Mack, CAASTRO-CoEPP Joint Workshop, Australia, February 2013

Measuring Cosmic Expansion with the Baryonic Acoustic Feature
Eyal Kazin, CAASTRO-CoEPP Joint Workshop, Australia, February 2013

Weak Lensing from IFU Spectroscopy: Direct Shear Mapping
Catherine de Burgh-Day, Combined SAMI and GAMA team meeting and workshop, Australia, February 2013

Gender is not a niche issue
Kate Gunn, CUDOS Annual Workshop, Phillip Island, Australia, February 2013

Transient surveys with 128T
Martin Bell, Murchison Widefield Array workshop, Perth, Australia, February 2013

MWA Ionospheric Calibration
Daniel Mitchell, Third workshop on third-generation calibration in radio astronomy (3GC3), Port Alfred, South Africa, February 2013

Shapelets and the MWA
Jennifer Riding, Third workshop on third-generation calibration in radio astronomy (3GC3), Port Alfred, South Africa, February 2013

MWA Calibration & Imaging
Daniel Mitchell, Third workshop on third-generation calibration in radio astronomy (3GC3), Port Alfred, South Africa, February 2013

Cosmic Magnetism
Bryan Gaensler, Colloquium, Harvard-Smithsonian Center for Astrophysics, USA, March 2013

What does the galaxy distribution tell us about the Universe
Chris Blake, CSIRO eResearch conference, Australia, March 2013

100 million years after the Big Bang
Jeremy Mould, GMT instrumentation, USA, March 2013

MWA: Lessons Learned
Frank Briggs, SKA1_Low science Assessment Workshop, UK, March 2013

Observing the EoR with the MWA
Randall Wayth, Synthetic Universes for Future Surveys, Perth, Australia, March 2013

Why we need you: confessions of an end user
Eyal Kazin, Synthetic Universes for Future Surveys, Perth, Australia, March 2013

Future Neutral Hydrogen Surveys with ASKAP
Alan Duffy, Synthetic Universes for Future Surveys, Perth, Australia, March 2013

Cosmological Simulations with GADGET-3: Update
Edoardo Tescari, Synthetic Universes for Future Surveys, Perth, Australia, March 2013

Effect of IGM on LAEs around EoR
Akila Jeeson-Daniel, Synthetic Universes for Future Surveys, Perth, Australia, March 2013

Ionisation Structure and 21-cm Power Spectrum with Realistic Galaxy Formation Models
Hansik Kim, Synthetic Universes for Future Surveys, Perth, Australia, March 2013

Dark Matter Particle Physics in Cosmological Simulations
Katie Mack, Synthetic Universes for Future Surveys, Perth, Australia, March 2013

Stacking and Intensity Mapping in Radio Astronomy
Lister Staveley-Smith, Modern Radio University, Bonn, Germany, April 2013

100 million years after the Big Bang
Jeremy Mould, Resolved Stellar Populations in the Galactic Bulge & The Clouds, Chile, May 2013

Cosmic Magnetism
Bryan Gaensler, Science at the Shine Dome, Canberra, Australia, May 2013

6dFGS Peculiar Velocities and Cosmography
Chris Springob, Cosmic Flows - Observations and Simulation Conference, France, June 2013

Velocity power spectrum -- simulation and observation
Jun Koda, Cosmic Flows - Observations and Simulation Conference, France, June 2013

The Baryonic Acoustic Feature in WiggleZ and BOSS
Eyal Kazin, Cosmoprobes, Switzerland, June 2013

What drives the diversity in narrow-line AGN spectra?
James Allen, Feeding, Feedback, and Fireworks, Hamilton Island, Australia, June 2013

Properties of Simulated Galaxies at z ~ 4-7
Edoardo Tescari, Feeding, Feedback, and Fireworks: Celebrating Our Cosmic Landscape, Hamilton Island, Australia, June 2013

Environmental Effects on Lyman Alpha Emitters at z = 3
Akila Jeeson-Daniel, Feeding, Feedback, and Fireworks: Celebrating Our Cosmic Landscape, Hamilton Island, Australia, June 2013

Director's Overview
Steven Tingay, MWA Project Meeting, University of Washington, USA, June 2013

Impact of observing strategy on EoR estimation
Cathryn Trott, MWA Project Meeting, University of Washington, USA, June 2013

An update on the MWA High Time Resolution System
Steven Tremblay, MWA Project Meeting, University of Washington, USA, June 2013

MWA Polarisation Update
Emil Lenc, MWA Project Meeting, University of Washington, USA, June 2013

Results from submitted paper on Centaurus A at 118 MHz observed with the MWA 32T
Ben McKinley, MWA Project Meeting, University of Washington, USA, June 2013

LOFAR and RFI
Andre Offringa, RFI and its impact on the new generation of HI spectral-line surveys, Sydney, Australia, June 2013

Progress in measuring the accelerating universe
Brian Schmidt, Science Foo Camp 2013, California, USA, June 2013

A search for intervening HI absorption in HIPASS galaxies
Sarah Reeves, SKA Pathfinders HI Survey Coordination Committee (PHISCC), Sydney, Australia, June 2013

Complementarity with Wallaby
Lister Staveley-Smith, TAIPAN Meeting, Sydney, Australia, June 2013

The importance of science communication (Panel Discussion)
Brian Schmidt, Annual Scientific Meeting, Astronomical Society of Australia, Australia, July 2013

First Polarisation results with the MWA
Emil Lenc, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Peculiar Velocity Power Spectrum
Jun Koda, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

A search for intervening HI absorption in nearby, gas-rich galaxies
Sarah Reeves, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Unveiling the Variable X-ray Sky
Sean Farrell, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Locations of Peculiar Supernovae as a Diagnostic of Their Origins
Fang Yuan, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

SN 2012fr: A Luminous Normal Type Ia Supernova in NGC 1365
Mike Childress, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

MWA: Epoch of Reionisation
Rachel Webster, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

The 2016-25 Decadal Plan for Australian Astronomy
Stuart Wyithe, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Properties of simulated galaxies at z ~ 4-7
Edoardo Tescari, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Properties of high redshift galaxies in cosmological hydrodynamic simulations
Antonios Katsianis, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

What can a gravitationally-lensed quasar teach us?
Rachel Webster, Annual Scientific Meeting, Astronomical Society of Australia, Melbourne, Australia, July 2013

Cosmology with the WiggleZ Survey and beyond
Chris Blake, LSS13 Workshop, Ascona, Switzerland, July 2013

100 Myrs after the Big Bang
Jeremy Mould, Reionisation in the Red Centre: New windows on the high redshift Universe, Uluru, Australia, July 2013

Understanding the Epoch of Reionisation using hierarchical galaxy formation models
Hansik Kim, Reionisation in the Red Centre: New windows on the high redshift Universe, Uluru, Australia, July 2013

Clumping factors of H and He from EoR simulations
Akila Jeeson-Daniel, Reionisation in the Red Centre: New windows on the high redshift Universe, Uluru, Australia, July 2013

Properties of simulated galaxies at z ~ 4-7
Edoardo Tescari, Reionisation in the Red Centre: New windows on the high redshift Universe, Uluru, Australia, July 2013

Dark Matter Particle Physics, Structure Formation, and Reionisation
Katherine Mack, Reionisation in the Red Centre: New windows on the high redshift Universe, Uluru, Australia, July 2013

Cosmology
Brian Schmidt, RSAA Winter school talk & Q&A, Canberra, Australia, July 2013

Moderated Discussion on Early ASKAP Science
Brian Schmidt, ASKAP Early Science Workshop, Sydney, Australia, August 2013

Early Polarisation Science with ASKAP
Bryan Gaensler, ASKAP Early Science Workshop, Sydney, Australia, August 2013

Searching for Fast Radio Bursts in the High Time Resolution Universe Survey
Emily Petroff, ATNF Student Symposium, Sydney, Australia, August 2013

Cosmology with TAIPAN
Chris Blake, TAIPAN Meeting, Sydney, Australia, August 2013

Peculiar velocity survey requirements
Chris Springob, TAIPAN Meeting, Sydney, Australia, August 2013

Milky Way Science
Jeremy Mould, 2013 OzDES Science Meeting, Sydney, Australia, September 2013

SAMI – A major step forward for galaxy surveys
Julia Bryant, Anglo-Australian Telescope, Siding Spring, Australia, September 2013

QSO reverberation mapping with OzDES
Rob Sharp, 2013 OzDES Science Meeting, Sydney, Australia, September 2013

Science from overlapping lensing / spec-z surveys
Chris Blake, 2013 OzDES Science Meeting, Sydney, Australia, September 2013

A search for intervening HI absorption in nearby galaxies
Sarah Reeves, CASS Student Symposium, Sydney, Australia, September 2013

Anti-hierarchical growth and feedback history of powerful radio galaxies
Anna Kapinska, Galaxy evolution across five decades, University of Cambridge, UK, September 2013

Kinematic morphology and its relationship to local and global environment
Nic Scott, Galaxy Zoo, Powerhouse Museum, Sydney, Australia, September 2013

HI velocity fields and rotation curves
Se-Heon Oh, Science Symposium for the ATCA 25th, Australia, September 2013

Direct Shear Measurement
Rachel Webster, Synergistic Science with Euclid and the Square Kilometre Array, Oxford, September 2013

Low frequency VLBI with SKA and its pathfinders
Anna Kapinska, Understanding the Radio Continuum Universe with SKA Pathfinders: The 3rd SKA Pathfinders Radio Continuum Surveys (SPARCS2013) meeting, UK, September 2013

Three ways to measure cosmic distances
Chris Blake, WiggleZ Meeting, Brisbane, Australia, September 2013

Pathways to Success in Science
Brian Schmidt, Women in Astronomy, Perth, Australia, September 2013

Panellist - Best Practice for Organisations
Bryan Gaensler, Women in Astronomy, Perth, Australia, September 2013

Detecting highly-dispersed bursts with next-generation radio telescopes
Evan Keane, ATNF Collaboration, Sydney, Australia, October 2013

The AT20G view of Swift/BAT selected AGN: high frequency radio waves meet hard X-ray
Davide Burlon, Black Holes, Jets and Outflows, Nepal, October 2013

Stellar Kinematics with SAMI
Lisa Fogarty, Deconstructing Galaxies, ESO, Chile, November 2013

Peer-Review: The Editor's Perspective
Bryan Gaensler, Early Career Researcher Refereeing workshop, Sydney, Australia, November 2013

Observing the EoR with Low Frequency Telescopes
Cathryn Trott, Gerfest - The Radio Universe @ meter wavelength, The Netherlands, November 2013

The MWA and the EoR, RFI and a new imaging algorithm
Andre Offringa, Gerfest - The Radio Universe @ meter wavelength, The Netherlands, November 2013

Primoridal Hydrogen: EoR++
Frank Briggs, Gerfest - The Radio Universe @ meter wavelength, The Netherlands, November 2013

Radial star formation rate profiles in the SAMI Survey
Adam Schaefer, SAMI busyweek, Mt Stromlo, Australia, November 2013

SAMI Target Selection
Julia Bryant, SAMI busyweek, Mt Stromlo, Australia, November 2013

Searches for Fast Radio Transients with Next Generation Telescopes
Evan Keane, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

Accelerated acceleration searching and the GPU revolution
Ewan Barr, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

FRB Origins - Conference Summary
Evan Keane, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

Searching for Fast Radio Bursts at Intermediate Latitudes
Emily Petroff, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

FRBs and recent work with MOST
Matthew Bailes, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

The V-FASTR fast transients project
Randall Wayth, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

Early Pulsar Observations with the MWA: Highlights from Recent Simultaneous Observations with Parkes
Ramesh Bhat, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

Prospects for the detection of FRBs with the MWA
Cathryn Trott, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

Transients detection rates and instrument design
Jean-Pierre Macquart, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

Searching for FRBs with the Murchison Widefield Array
Samuel Oronsaye, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

Current and future data capture and offline processing possibilities with the MWA; how, when and why?
Stephen Ord, The Ephemeral Universe with Low Frequency Arrays, Perth, Australia, November 2013

Redshift-space Distortions of Peculiar Velocity Field
Jun Koda, 27th Texas Symposium on Relativistic Astrophysics, USA, December 2013

Cosmology with the WiggleZ Survey
Chris Blake, AAO Planning Day, Sydney, Australia, December 2013

Applications of blind source separation to extragalactic spectroscopic surveys
James Allen, Astroinformatics, CASS, Sydney, Australia, December 2013

Polarisation with the Murchison Widefield Array
Emil Lenc, MWA EoR Busy Week, Wellington, New Zealand, December 2013

Observations of Giant Pulses from the Crab Nebula Pulsar
Samuel Oronsaye, MWA EoR Busy Week, Wellington, New Zealand, December 2013

Early commissioning of the MWA Voltage Capture System
Steven Tremblay, MWA EoR Busy Week, Wellington, New Zealand, December 2013

A multiwavelength analysis of Fornax A
Ben McKinely, MWA Project Meeting, University of Wellington, New Zealand, December 2013

GLEAM
Randall Wayth, MWA Project Meeting, University of Wellington, New Zealand, December 2013

The MWA imaging and noise performance
Andre Offringa, MWA Project Meeting, University of Wellington, New Zealand, December 2013

Improved distance measurements with reconstructed WiggleZ
Eyal Kazin, Seventh Australasian Conference on General Relativity and Gravitation, Hamilton Island, Australia, December 2013

Characterising diffused stellar light in simulated galaxy clusters
Weiguang Cui, ICRAR Seminar Series, Perth, Australia, December 2013

Cosmology and Cosmography from the 6dFGS and 2MTF Peculiar Velocity Surveys
Chris Springob, University of Queensland, Brisbane, Australia, December 2013

International Visitors to CAASTRO in 2013

Filipe Abdalla
University College London, UK

Carlton Baugh
Institute for Computational Cosmology, Durham University, UK

Gianni Bernardi
Harvard-Smithsonian Center for Astrophysics, USA

Florian Beutler
University of California, Berkeley, USA

Michael Boer
Centre National de la Recherche Scientifique (CNRS) - ARTEMIS, France

Jayaram Chengalur
National Centre for Radio Astronomy, India

Geoffrey C. Clayton
Louisiana State University, USA

Steve Croft
University of California, Berkeley, USA

Ciro Danalek
California Institute of Technology, USA

Roger Davies
University of Oxford, UK

Marc Davis
University of California, Berkeley, USA

Avinash Deshpande
Raman Research Institute, Bangalore, India

Mark Dijkstra
Max Planck Institute for Astrophysics, Garching, Germany

George Djorgovski
California Institute of Technology, USA

Simona Gallerani
Astronomical Observatory, Rome, Italy

Giancarlo Ghirlanda
INAF - Osservatorio Astronomico di Brera, Italy

Luca Graziani
Max Planck Institute for Astrophysics, Garching, Germany

Gregg Hallinan
California Institute of Technology, USA

Jason Hessels
ASTRON, The Netherlands

Jake Hughes
Cardiff University, Wales

Daniela Huppenkothen
University of Amsterdam, The Netherlands

Nie Jun
Xinjiang Astronomical Observatory, Chinese Academy of Sciences, China

Leon Koopmans
Kapteyn Astronomical Institute, University of Gronigen, The Netherlands

Claudia Lagos
European Southern Observatory, Germany

Di Li
National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China

Karen Masters
University of Portsmouth, UK

Emily McLinden
McDonald Observatory, University of Texas, USA

Matthew Middleton
University of Amsterdam, The Netherlands

Daniel Mortlock
Imperial College London, UK

Stephen Ng
Hong Kong University, China

Mark Phillips
Carnegie Institution for Science, USA & Las Campanas Observatory, Chile

Philip Podsiadlowski
University of Oxford, UK

Luciano Rezzolla
Max-Planck-Insitut fur Gravitationsphysik, Germany

Ariel Sanchez
Max Planck Institute for Extraterrestrial Physics, Garching, Germany

Vernesa Smolčić
University of Zagreb, Croatia

Snežana Stanimirović
University of Wisconsin, USA

Jill Tarter
SETI (Search for Extraterrestrial Intelligence) Institute, USA

Jackob Walcher
Leibniz Institute for Astrophysics Potsdam, Germany

Peter Williams
Harvard-Smithsonian Center for Astrophysics, USA

Rogier Windhorst
Arizona State University, USA

Laura Wolz
University College London, UK

Visits to overseas laboratories and facilities in 2013

Matthew Bailes
Aspen Center for Physics Colorado, USA

Matthew Bailes
University of Cape Town, South Africa

Martin Bell
Southampton University, UK

Martin Bell
University of Washington, Seattle, USA

Ramesh Bhat
Giant Metrewave Radio Telescope, Khodad, India

Ramesh Bhat
National Centre for Radio Astrophysics (NCRA), Pune, India

Chris Blake
University College London, UK

Chris Blake
University of British Columbia, USA

Chris Blake
University of California, USA

Chris Blake
University of Edinburgh, UK

Chris Blake
University of Manchester, UK

Frank Briggs
University of Groningen, The Netherlands

Frank Briggs
International Square Kilometre Array Headquarters, Jodrell Bank, UK

Frank Briggs
University of Wellington, New Zealand

Julia Bryant
Nanjing Institute of Geology and Palaentology, Nanjing, China

Joseph Callingham
University of Washington, Seattle, USA

Mike Childress
Las Cumbres Observatory, USA

Mike Childress
Lorentz Centre, Leiden, The Netherlands

Mike Childress
PESSTO Observatory, Padova, Italy

Mike Childress
Sant Feliu de Guixol, Barcelona, Spain

Steve Curran
Durham University, UK

Steve Curran
Onsala Space Observatory, The Swedish National Facility for Radio Astronomy, Sweden

Steve Curran
University of Oxford, UK

Tamara Davis
SLAC National Accelerator Laboratory, California, USA

Tamara Davis
Lawrence Berkeley National Laboratory, California, USA

Tamara Davis
University of Copenhagen, Denmark

Tamara Davis
Danish Technical University, Denmark

Tamara Davis
University of Edinburgh, UK

Wiebke Ebeling
Bryant University, Rhode Island, USA

Lisa Fogarty
ESO Santiago, Chile

Bryan Gaensler
Dominion Radio Astrophysical Observatory, Penticton, Canada

Bryan Gaensler
Harvard-Smithsonian Center for Astrophysics, Boston, USA

Bryan Gaensler
International Square Kilometre Array Headquarters, Jodrell Bank, UK

Bryan Gaensler
Nanjing Institute of Geology and Palaeontology, Nanjing, China

Bryan Gaensler
University of Washington, Seattle, USA

Paul Hancock
International Virtual Observatory Alliance, Germany

Paul Hancock
Nanjing Institute of Geology and Palaeontology, Nanjing, China

UNITE.

Paul Hancock
University of Wellington, New Zealand

Andrew Johnson
University College London, UK

Eyal Kazin
University College London, UK

Eyal Kazin
Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland

Jun Koda
Institut Astrophysique de Paris, France

Jun Koda
Leibniz Institute for Astrophysics Potsdam, Germany

Jun Koda
University of Texas, USA

David Lagattuta
Lisbon University, Portugal

David Lagattuta
Institut de Fisica d'Altes Energies (IFAE), Barcelona, Spain

Emil Lenc
University of Washington, Seattle, USA

Daniel Mitchell
Harvard-Smithsonian Center for Astrophysics, Boston, USA

Daniel Mitchell
University of Washington, Seattle, USA

Jeremy Mould
Carnegie Observatories, CA, USA

Jeremy Mould
College Station Texas, USA

Jeremy Mould
Cerro Tololo Inter-American Observatory (CTIO), Chile

Jeremy Mould
Keck Observatory, USA

Andre Offringa
University of Groningen, The Netherlands

Andre Offringa
Rhodes University and the Centre For Radio Astronomy Techniques & Technologies, South Africa

Chris Power
University of Cape Town, South Africa

Pietro Procopio
University of Wellington, New Zealand

Sarah Reeves
ESO, Garching, Germany

Jennifer Riding
National Centre for Radio Astrophysics (NCRA), Pune, India

Elaine Sadler
Lorentz Centre, Leiden, The Netherlands

Brian Schmidt
Fundacion BBVA Madrid, Spain

Brian Schmidt
Haus der Adtronomie Heidelberg, Germany

Brian Schmidt
Kirchhoff Institute for Physics, Germany

Brian Schmidt
Leibniz Kolleg Institute, Germany

Brian Schmidt
McGill University Montreal, Quebec, Canada

Brian Schmidt
PESSTO Observatory, Padova, Italy

Brian Schmidt
Raman Research Institute, India

Brian Schmidt
Autonomous University of Madrid, Spain

Brian Schmidt
University of Alaska, USA

Brian Schmidt
University of Zurich, Switzerland

Paul H Scott-Taylor
Carnegie Observatories, CA, USA

Morag Scrimgeour
University of California, Berkeley, USA

Chris Springob
Aix Marseille University, France

Lister Staveley-Smith
Academia Sinica, Taiwan

Lister Staveley-Smith
ESO, Garching, Germany

Lister Staveley-Smith
National Center for Radio Astrophysics, Tata Institute of Fundamental Research, Pune, India

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Edoardo Tescari
Department of Physics, Astronomy Section, University of Trieste, Italy

Steven Tingay
California Institute of Technology, USA

Steven Tingay
University of Washington, Seattle, USA

Steven Tingay
University of Wellington, New Zealand

Patrick Tisserand
Laboratoire Physique Nucléaire et de Hautes Énergies, Paris, France

Patrick Tisserand
SOAR, Chile

Steven Tremblay
University of Washington, Seattle, USA

Willem van Straten
Aspen Centre for Physics, Colorado, USA

Randall Wayth
University of Washington, Seattle, USA

Rachel Webster
University of Wellington, New Zealand

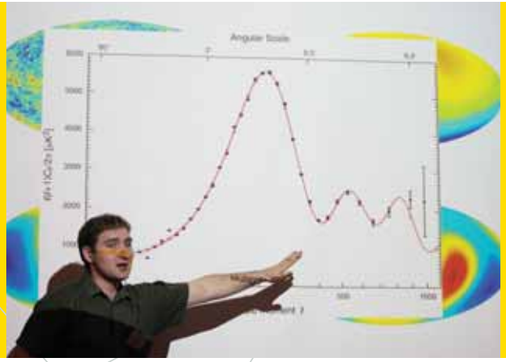
Stuart Wyithe
Gemini South Telescope, International Gemini Partnership, La Serena, Chile

Stuart Wyithe
Max Planck Institute, Garching, Germany

Fang Yuan
Tsinghua Center for Astrophysics, Tsinghua University, Beijing, China

Dr Julia Bryant (left) and CAASTRO Chair, Dr Alan Finkel AM (right) at the 10th China Australian Symposium on Science at Technology in Nanjing, China
Credit: Bryan Gaensler

WORKSHOPS



SURFS Workshop (Left)

Chris Power at SURFS Workshop (Right)
Credit: Aaron Robotham

CAASTRO hosted a number of interesting and stimulating international workshops during 2013.

Synthetic Universes for Future Surveys (SURFS) Workshop

The 1st "Synthetic Universes for Future Surveys" (SURFS) workshop was held at the University Club at the University of Western Australia on 21 and 22 March 2013. The workshop brought together 40 theorists, simulators and observers from around Australia and overseas (including the USA, Germany, Spain, the UK and South Africa) with the objectives to review the state-of-the-art in cosmological simulations and galaxy formation modelling and to critically assess what is required if such modelling is to meet the demands of next generation galaxy surveys.

The first day was split between reviewing the state-of-the-art in simulation, modelling and synthetic surveys (Themes 1 and 2), and cold gas in galaxies and the radio sky (Themes 3 and 4). Highlights included keynote speaker Andrew Benson (Carnegie Observatories, USA), who argued that current semi-analytical models of galaxy formation provide a powerful physical framework, but that a more quantitative statistical approach is required to ensure that the models are predictive and able to provide reliable simulation of future surveys.

Highlights of the first Theme included: Claudia Lagos (ESO Garching, Germany) who explained how the demands of surveys of cold gas in galaxies have driven recent improvements in the modelling of the interstellar medium (ISM) in semi-analytics; Simon Mutch (University of Melbourne), who showed that a galaxy formation model with as few as two parameters that link a galaxy's star formation history to its host halo growth predicts a galaxy population that is in qualitative agreement with observations; Alexander Knebe (Universidad Autonoma de Madrid, Spain) revealed that widely used methods for identifying dark matter haloes and their substructure in cosmological simulations, on which galaxy formation modelling is based, produce results that differ by tens of percent; and Darren Croton (Swinburne), who reviewed the Theoretical Astrophysics Observatory that will deliver synthetic galaxy surveys generated from semi-analytical models to the wider astronomy community.

The third and fourth Themes, relating to cold gas in galaxies and the radio sky, featured a mixture of talks on simulations, modelling and observational surveys. Danail Obreschkow (ICRAR/UWA) showed how synthetic universes carefully constructed according to precise selection criteria can help aid interpretation of observational results, focussing on his recent work understanding what the velocity function of HI-selected galaxies can tell us about the nature of dark matter. Alan Duffy (University of Melbourne) presented a step-by-step guide on creating synthetic HI surveys tailored to the WALLABY all-sky and DINGO pencil-beam surveys on ASKAP, complementing the observational perspective offered by Martin Meyer (ICRAR/UWA), who gave an overview of the science drivers for forthcoming HI surveys. Matt Whiting (CSIRO) explained why synthetic surveys are useful in survey design, focussing on the problem of source detection in radio datacubes, while Ray Norris (CSIRO) and Elaine Sadler (University of Sydney) reviewed the science driving the EMU radio continuum and FLASH HI absorption surveys on ASKAP respectively.

The second day included sessions on the optical sky (Theme 5), the high redshift Universe (Theme 6) and tests of non-standard cosmologies (Theme 7). Highlights included reviews of survey science with SAMI, the new integral field spectrograph on the AAT, by Geraint Lewis (University of Sydney) and the properties of Milky Way analogues in the Galaxy and Mass Assembly (GAMA) survey by Aaron Robotham (ICRAR/UWA). Eyal Kazin (Swinburne) provided an illustration of how cosmological simulations are helping observers model the reconstruction of the signature of baryon acoustic peaks in the matter density field; and Chiara Tonini's (Swinburne) description of how careful stellar population synthesis modelling allied to semi-analytics helped to explain the luminosity evolution of brightest cluster galaxies.

Randall Wayth (ICRAR/Curtin UT) opened Theme 6 with a review highlighting the potential of the MWA as an instrument for probing the global 21cm HI signal of the Epoch of Reionisation (EoR). Hansik Kim (University of Melbourne) showed results from his semi-analytic model of the EoR that suggests that the effect of supernovae at high redshifts on quenching star formation in galaxies might be evident in the 21cm HI power spectrum. Katie Mack (University of Melbourne) gave an overview of how the particle physics of dark matter could affect structure formation in the high redshift Universe, while Akila Jeeson Daniel (University of Melbourne) argued that the observed properties of Lyman-alpha emitters at high redshifts could contain information about galactic outflows into the intergalactic medium, based on the results of cosmological hydrodynamic simulations.

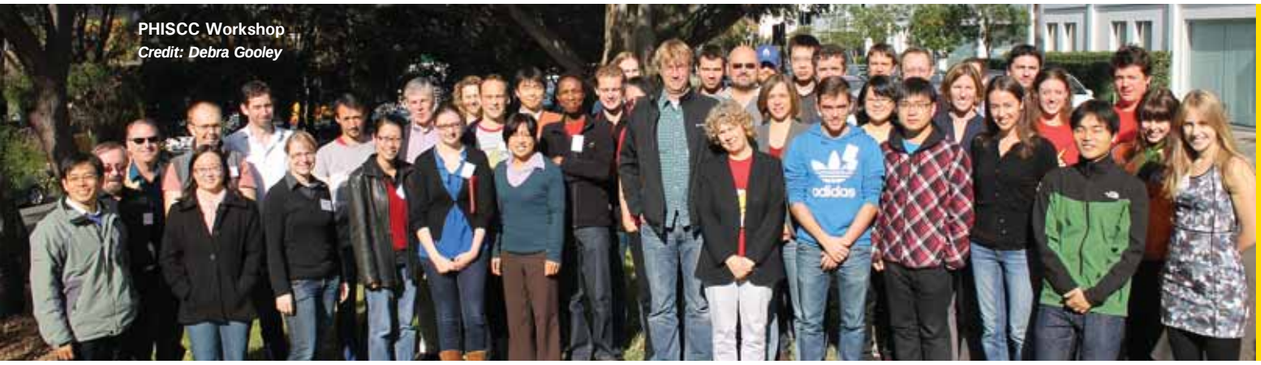
The meeting closed with break-away group discussions on topics ranging from tests of non-standard cosmologies to the high redshift Universe to cold gas in galaxies.

The 1st SURFS workshop was a success. It got theorists, simulators and observers talking to each other and grappling with the same questions, and it identified aspects of the modelling where more work is needed as well as forging new collaborations to carry out this work.

SURFS Workshop
Credit: Aaron Robotham

Eyal Kazin and Alexander Knebe in discussion, SURFS Workshop,
Credit: Aaron Robotham

Delegates at the SURFS Workshop.
Credit: Aaron Robotham



PHISCC Workshop
Credit: Debra Gooley

Ephemeral Universe Workshop
Credit: Mark Waterson

Ephemeral Universe Workshop
Credit: Mark Waterson

PHISCC Workshop

"Galaxy Velocity Fields from Large HI and Optical Surveys"

The SKA Pathfinders HI Survey Coordination Committee (PHISCC) holds regular international meetings to discuss scientific and technical issues relevant to future large neutral hydrogen (HI) surveys with the Square Kilometre Array and its pathfinder and precursor telescopes. A key aim of these meetings is to identify areas where collaboration between the SKA pathfinder teams can be mutually beneficial.

The 6th International PHISCC Workshop took place in Sydney during the week of 17-21 June 2013, sponsored by CAASTRO, CSIRO Astronomy and Space Science (CASS) and the Australian Astronomical Observatory (AAO).

This meeting had two related strands. A technical workshop on radio-frequency interference, "RFI and its impact on the next generation of HI spectral-line surveys" was held at CSIRO in Marsfield on 17-18 June, and a science workshop on "Galaxy velocity fields from large HI and optical surveys" was held at CAASTRO headquarters in Redfern on 19-21 June. Each of these workshops was attended by more than 50 participants from Australia and overseas, with the international participants coming from Canada, China, Korea, the Netherlands, South Africa and the USA.

Terrestrial radio-frequency interference (RFI) from sources like TV transmitters, mobile phones, aircraft beacons and communications satellites can easily drown out the faint radio signature of the redshifted 21cm hydrogen line in distant galaxies. As well as building new radio telescopes in remote sites far from large cities, it is therefore important to pay careful attention to monitoring terrestrial RFI signals and mitigating their effects wherever possible.

The presentations at the 17-18 June RFI workshop included information on measurements and monitoring of the current RFI environment at radio observatories around the world; site protection and the current regulatory environment; and techniques for identifying and removing RFI signals from astronomical data. This is an area where international collaboration is particularly valuable, and it was very useful to be able to bring astronomers and engineers together for a detailed discussion of the 'real-life' problems which RFI presents for wide-band HI spectral-line surveys with existing and future radio telescopes.

The PHISCC science workshop on 19-21 June provided a general update on progress and plans for upcoming HI surveys on SKA Pathfinder and Precursor telescopes around the world, but also had a special focus on the techniques, tools and plans for future studies of galaxy velocity fields with large optical and radio surveys. The aim here was to identify and build on synergies between next-generation HI surveys, which will measure the detailed kinematics of neutral gas in nearby galaxies, and a new generation of large integral-field (IFU) optical surveys like the Australian-led SAMI project, which can measure the kinematics of ionised gas and stars in many of the same galaxies. The workshop was able to identify several areas of common interest, such as kinematic modelling and visualisation. As one of the speakers remarked, there is clearly a bright scientific future for joint HI and optical IFU surveys.

In all, there were almost 40 scientific presentations at this workshop, as well as opportunities for discussion between presentations, during morning and afternoon tea breaks, and over dinner at a local restaurant. There was also a longer and more structured panel discussion on the recently-released SKA1 Baseline Design document. This identified a number of questions and issues which the PHISCC members will bring to the attention of the SKA Project Office for further discussion. In addition, the PHISCC committee members (and invited observers) held an evening planning meeting to discuss the committee's priorities for the coming year.

This international PHISCC workshop provided a successful and collegial forum for meetings and discussions, as well as an impressive list of scientific projects and technical challenges (RFI, data processing, software tools and techniques) for future collaborative work. The next PHISCC workshop will be held in the Netherlands in March 2014.

Ephemeral Universe with Widefield Low Frequency Arrays workshop

Held at the Curtin Institute of Radio Astronomy in Western Australia from 12–14 November 2013, this workshop attracted 48 participants, with 11 of them international visitors, including Scott Ransom (NRAO), Paul Ray (NRL), Robert Braun (SPO), Andy Faulkner (Cambridge), Jason Hessels (ASTRON) and Jan Geralt bij der Vaate (ASTRON; LFAA consortium leader). There was also representation from the Swinburne, University of Western Australia and University of Sydney CAASTRO nodes. In addition to the registered talks, we fielded virtual talks from Rob Fender (Oxford) and Laura Spitler (MPIfR).

Three themes emerged from the meeting:

1. The interchange between the theoretical and observational (facilitated by Don Melrose and Ron Ekers), particularly as it related to puzzles that have existed since the 1960's and 1970's that have still not been resolved.
2. The observational properties and reality of fast radio bursts, and how to explain their various characteristics. The argument at the end of the first day on the scintillation properties of pulsars off the Galactic plane, which may relate to the Galactic latitude dependence of FRB detections, became quite spirited. It became clear that the verification and localisation of FRBs is a pressing issue, and it is one that fed directly into the ensuing discussion on the SKA.
3. Desirable specifications for SKA1-low as a pulsar and transients detection machine, including discussions on the optimal frequency range, configuration, station size, signal buffer and signal processing chain. The presence of Robert Braun, Andy Falkner, Peter Hall and Jan Geralt bij de Vaate and the virtual presence of Rob Fender made this discussion worthwhile.

In all, the meeting was an extremely lively one, with all talks generating considerable discussion.

2013 Women in Astronomy Workshop: Pathways to Success

The ASA Women in Astronomy workshops conducted over the past two years have explored the important issues of unconscious biases and leadership development for women. The workshops have encouraged astronomy institutions in Australia to support and implement policies and systems to ensure that women can fully participate and excel in their academic careers and also help with their family and work-life balance.

This trend was further strengthened in the third workshop held on 11-12 September in Perth. The 2-day workshop was hosted by the International Centre for Radio Astronomy Research (ICRAR) and was co-sponsored by CAASTRO once again in 2013. It focussed on "Pathways to Success" for women in academic and alternate careers, and further unpacked issues that hold women back from progressing in their careers. This was also an opportunity for courageous conversations about gender and women's leadership. Eminent guest speakers from academia and industry addressed the workshop, which had a mix of talks and interactive sessions.

SAMI Team Meeting February 2013. *Photo: Lisa Fogarty*

How To Be an Effective Referee

On 29 November 2013, CAASTRO hosted an interactive workshop run by the Early Career Researcher Chapter of the Astronomical Society of Australia (ASA) at our Redfern office at the University of Sydney. The session proved invaluable to attendees who learned not only about being an effective referee, but how to respond to referees' comments.

Exploring the Radio Transient Sky

On 5th and 6th December 2013, CAASTRO hosted the VAST Workshop, "Exploring the Radio Transient Sky" at our Redfern office at the University of Sydney. 35 people came together at to hear an excellent line-up of invited speakers, covering a range of topics related to the science we can do on slow transients with ASKAP. Some of the highlights were Brian Schmidt's talk on optical and radio synergies, George Djorgovski's talk on lessons learned from optical time domain astronomy projects, and Giancarlo Ghirlanda's talk on the detectability of gamma-ray burst afterglows with ASKAP.

We also had a lot of lively discussion, in particular on what early science we plan to do with ASKAP over the next year. Several new observing projects were planned over lunch and afternoon tea, which resulted in some ATCA proposals that have been awarded time in the current semester.

Other Workshops and Meetings

There were a number of other activities during the year, with the SAMI and MWA teams being the most active. SAMI held a team meeting from 13–14 February, a SAMI busy week 29 May until 3 June and a second SAMI busy week from 4 to 8 November.

The MWA had busy weeks/meetings in February, April, May, June and October, held in Canberra, Melbourne, Seattle and Perth.

MWA Commissioning Busy Week in Perth
Credit: Emil Lenc

CONFERENCES

REIONISATION IN THE RED CENTRE:

New Windows on the High-Redshift Universe

The CAASTRO "Reionisation in the Red Centre" Science Conference was held from 15 until 19 July 2013. This conference was the first in the annual series of CAASTRO conferences in wide-field astronomy, and took place at the Ayers Rock Resort in the shadow of outback Australia's iconic Uluru. The meeting was very successful, attracting a total of 74 participants from 9 countries, with more than half visiting from overseas. The countries represented included Australia (35), USA (21), Germany (6), UK (4), China (2), Italy (2), Netherlands (2), Denmark (1), and Japan (1). The conference featured 11 invited and 28 contributed talks.

A key goal of the meeting was to provide a multi-wavelength and multi-technique discussion of the outstanding questions in reionisation research. The attendees included representatives from optical/IR telescopes including the Hubble Space Telescope and James Webb Space Telescope; radio telescopes including ALMA, the Murchison Widefield Array, PAPER, LOFAR, and CORE; as well as major instruments and surveys including MOSFIRE, COS, IRAC, HETDEX, and CANDELS. These current and future observational efforts were complemented by a good representation from numerical simulation groups, including discussion of results from 21cmFAST, DRAGONS, TRAPHIC, and GADGET. This interplay between observation and theory is crucial for comparison of methods, and interpretation of results.

The formation of the first stars, galaxies and black holes, and the associated reionisation of cosmic hydrogen and helium represent one of the major events in cosmic history, and is a key facet of the CAASTRO Evolving Universe program. This topic has received a great deal of attention over the past decade, with a focus on theory and interpretation of the first observations of the reionisation era. The study of early galaxy formation and reionisation is now entering a new era, facilitated by the impending availability of a range of revolutionary telescopes, which will complement current optical/near-IR deep and wide-field surveys. The aim of the Reionisation in the Red Centre conference was to bring together theorists and observers to present recent advances in our understanding of cosmic reionisation and the high redshift Universe, and to discuss how new observational capabilities will drive the science in the future.

The topics discussed included:

- What have we learned about reionisation from the cosmic microwave background?
- What do we know about the history of the intergalactic medium?
- What do we know about early stars and galaxies?
- What do we know about early black holes and quasars?
- What are 21cm studies teaching us about reionisation?
- How well has theory confronted observations in the realm of reionisation?
- What are the key future observations for understanding reionisation?

A particularly timely session was devoted to an update on new observational programs aimed at probing reionisation via the redshifted 21cm line of hydrogen. Results shown included very impressive early images from the newly operational Murchison Widefield Array. The meeting also heard about the alternative approach being taken to measure the 21cm signal by the PAPER collaboration, as well as the first physically meaningful limits from that experiment. Finally, the meeting heard of progress on LOFAR, including the exciting prospect that the first solid reionisation results are expected within 1 year. In each case radio reionisation studies will need to mitigate strong foregrounds. Each group considered this achievable through various observing strategies, but this remains a primary challenge.

In addition to the new radio telescopes that have recently commenced observation, the meeting heard reports of new observational programs at optical & IR wavelengths using the Hubble Space Telescope. With the recent completion of the Extremely Deep Field, new searches for high-redshift galaxies are underway, with ~100 galaxies now known at $z \sim 8$. Intriguingly, even at this early time only 600 Myr after the Big Bang, galaxies show relatively old stellar populations (> 100 Myr).

While the redshifted 21cm and optical/IR searches have received most of the attention in studies of reionisation to date, the meeting also heard updates on new observational programs aimed at measuring small-scale

Reionisation in the Red Centre *Credit: Kim Dorrell*

fluctuations in the cosmic microwave background using the South Pole Telescope to probe the kinetic Sunyaev-Zel'dovich effect. This will provide independent constraints on the timing and duration of reionisation. While this measurement is in its early stages, both from the observational and theoretical point of view it remains very promising.

The meeting discussed a range of recent results. Reionisation is thought to be an extended process, which is complete by $z \sim 6$ as seen in quasar spectra, but which started as early as $z \sim 10$-11 according to measurements from the cosmic microwave background. Based on the newest deep observations from the Hubble Space Telescope, it is now becoming clear that galaxies were responsible for this reionisation, with quasars contributing only a small fraction based on constraints from x-rays and intergalactic medium temperature. At the highest redshift, these reionising galaxies tend to be blue, small and faint. Of importance for reionisation was the new finding that the colour based selection of Lyman-Break Galaxies may be missing those galaxies from which the ionising radiation can escape, which could be introducing an important bias in high redshift galaxy samples.

In addition to the results presented, the meeting also highlighted a range of open questions, including how the observed supermassive black holes could be in place at high redshift (less than 0.6 Gyr after Big Bang)? What is the IGM clumping factor that regulates the rate at which reionisation is counteracted by recombinations at high redshift? How do nebular emission lines affect estimates of stellar mass in high-redshift galaxies? These are some of the questions that will be answered in the next few years as part of our effort to understand the formation of the first stars, galaxies and black holes, and the reionisation of cosmic hydrogen.

An early morning camel ride
Credit: Damien Hill from Uluru Photography

Bryan Gaensler and Lister Staveley-Smith with the invited speakers

Physical fitness on the beach

Golf Cart Rally with Brian Schmidt and Matthew Bailes.

Winners of the Golf Cart Rally (L to R) Signe Riemer-Sorensen, Nicholas Scott, Hansik Kim and Martin Bell.

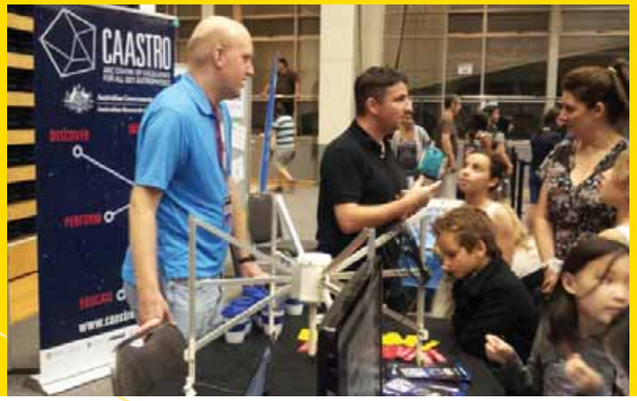
CAASTRO ANNUAL RETREAT

The third Annual CAASTRO Retreat was this year held in Torquay, Victoria from 20 to 22 November 2013. The Retreat was attended by 86 members and visitors who enjoyed over 25 science sessions which were grouped by theme. This year we also included a number of lively panel discussions. Our invited speakers included Dr Philip Podsiadlosi, University of Oxford, Professor Carlton Baugh, Durham University and Professor Marc Davis from the University of California, Berkeley.

A surprise team activity - an exciting golf cart rally - saw some intense competition amongst the teams with the eventual winners pictured below. An early morning yoga session and a lively personal training session ensured that our members enjoyed the outdoors and exercise as well as science. The Annual Retreat is always considered one of our most useful networking and collaboration events, and provides everyone with an opportunity to review the year and our successes together.

Annual Retreat delegates

EDUCATION & OUTREACH



Chris Springob and Chris Power at the CAASTRO info stall at Perth's Astrofest
Credit: Wiebke Ebeling

SCHOOL & PUBLIC OUTREACH

"CAASTRO in the Classroom" program branches out

Locally coordinated by Dr Jamie Farnes and Dr Shane O'Sullivan at the University of Sydney, CAASTRO's school engagement program "CAASTRO in the Classroom" delivers astrophysics presentations to High Schools in New South Wales via video conferencing technology. The program was still going strong in its second year with over 20 sessions offered across the four school terms in 2013. We were successful in having 30 schools dial in and over 400 students participate. While the majority of speakers were CAASTRO members from our Australian node locations, non-members were also invited to participate, including University of Sydney Professor Ben Eggleton from our sibling centre CUDOS, the ARC Centre of Excellence for Ultrahigh Bandwidth Devices for Optical Systems. This influx of expertise in non-CAASTRO research areas further broadens the program's reach and aids alignment with the national curriculum. "CAASTRO in the Classroom" sessions during the month of November were jointly held with the "Connections" project of the New South Wales Department of Education and Communities unit – Distance and Rural Technologies (DART), promoting virtual excursions for departmental and non-departmental schools and TAFEs in New South Wales.

A major milestone in the "CAASTRO in the Classroom" program in 2013 was a first trial run to collaborate with High Schools overseas. Dr Fang Yuan at the Australian National University organised a special session with three schools in China and helped out where language issues arose. Physics teachers and students from Beijing Huijia Private School, Hangzhou Senior High School, and Akesu High School (Xinjiang Province, northwestern China) contributed to an excellent interactive question and answer session. This successful trial has encouraged us to pursue such collaborations further and reach out to international student audiences where feasible.

Partnering with Mount Burnett Observatory in Melbourne's Eastern fringes

Together with the enthusiastic team around Dr James Murray, outreach officer at Mount Burnett Observatory in the Dandenong ranges, CAASTRO organised a 2-day astronomy festival for schools in May 2013. Four of our Melbourne-based postdoctoral staff and students, Dr Akila Jeeson-Daniel, Dr Alan Duffy, Dr Eyal Kazin, and Syed Uddin, participated in the event and gave talks to a total of 530 primary school students from six schools. While the Mount Burnett volunteers looked after the logistics on their grounds, CAASTRO organised a coach shuttle to transport students and teaching staff from their schools to the observatory and back. Not only were excursion and talks well received by all participants, who are generally less exposed to astronomy outreach than schools in the metropolitan area, but local press also took an interest in this activity and congratulated Dr Murray on his engagement. Mount Burnett Observatory remains an active outreach partner for CAASTRO for public evening talks throughout the year and National Science Week 2014.

Eyal Kazin's presentation to Gembrook Primary at the Mount Burnett astro festival. ***Credit: James Murray***

Showcasing CAASTRO research to the public

With the CAASTRO Education and Outreach team producing a large number of high quality research stories for the news section on the CAASTRO website, we found a valuable opportunity to further re-use and distribute them by collating them in the "CAASTRO Reader's Digest" booklets. In 2013, two editions (over 1,000 booklets each) were printed and made available to all CAASTRO nodes, national and international partners, the Advisory Board, as well as our outreach collaborators. Containing accurate accounts of current CAASTRO research, these booklets have proven particularly popular with amateur astronomy societies, science centres, and High School students involved in the "Telescopes in Schools" program. They were also included in the participants' bags at CAASTRO's 2013 Annual Science conference "Ionisation in the Red Centre" at Uluru and "The Ephemeral Universe with Low Frequency Arrays" workshop in Perth.

With the Murchison Widefield Array (MWA) in full science mode since mid 2013, public interest in displays of our MWA antenna tiles has been renewed. CAASTRO Education and Outreach therefore installed a full-size tile at the Gravity Discovery Centre in Gingin, Western Australia, and a reduced-size tile at Victoria University of Wellington, New Zealand, as well as provided the components and a construction manual for a travelling exhibit to the WA Museum. Collaborations with other locations, including the Canberra Deep Space Communication Complex, the National Science and Technology Centre (Questacon), and the Royal Institute of Australia (RiAus) in Adelaide, have been established for further MWA tile displays. Individual antenna elements were used for "show and tell" at Astrofest and in the foyer of the Pawsey Supercomputing Centre in Perth.

The Education and Outreach team can further rely on CAASTRO's passionate members who seized numerous opportunities throughout 2013 to give public astronomy talks. Our members at Swinburne University of Technology, for instance, are excellent contributors to the Swinburne public astronomy lecture series, with Dr Eyal Kazin, PhD student Syed Uddin, and Chief Investigator A/Prof Chris Blake having presented their research this year. Sparked by the commencement of science operations, Director of the Murchison Widefield Array and CAASTRO Executive member Prof Steven Tingay was invited to tell the MWA's story at various venues across Perth. Later in 2013, our Chief Investigator A/Prof Tamara Davis at the University of Queensland contributed to the TEDx Brisbane program with her expertise in Dark Matter and Dark Energy, and Nobel Laureate Prof Brian Schmidt gave the Bok lecture at Siding Springs Observatory near Coonabarabran in New South Wales.

CAASTRO also brought several high-profile science communicators to Australia for National Science Week, and Professor Bryan Gaensler featured in the children's television science series "Enquiring Minds".

MWA tile display at the Gravity Discovery Centre in Gingin, Western Australia ***Credit: Anja Cherian***

EDUCATE

Winning entries on display in Melbourne Planetarium foyer at Scienceworks
Credit: Jacinta den Besten

Social Network	Pageviews	Pageviews	Contribution to total: Pageviews
1. Facebook	2,909	49.88%	
2. Twitter	2,310	39.61%	
3. reddit	464	7.96%	
4. YouTube	80	1.37%	
5. Blogger	21	0.36%	
6. Delicious	11	0.19%	
7. Weebly	11	0.19%	
8. WordPress	11	0.19%	
9. HootSuite	5	0.09%	
10. Google+	4	0.07%	

Use of social media to communicate CAASTRO science
Credit: Wiebke Ebeling

Alan Duffy and Katie Mack host the 'Pint in the Sky' astro pub chat *Credit: Wiebke Ebeling*

Ongoing support of "Telescopes in Schools" program

Having operated for two years now, the University of Melbourne "Telescopes in Schools" program has successfully deployed its ten telescopes to schools across the city and regional centres and trained up teachers and students to operate them.

CAASTRO is a proud supporter of the program, with a number of our University of Melbourne members also helping out at observing sessions, for instance CAASTRO PhD student Bradley Greig and Affiliate Dr Alan Duffy at Footscray City College and Dr Katie Mack at Northcote High School.

In 2013, the program introduced a new capability and challenge in that cameras were attached to the telescopes, and entries into an astrophotography competition were invited. Students and teachers (not only those with a focus on Physics), as well as program volunteers, had the opportunity of a professional development session at Quantum Victoria ahead of the competition deadline to learn from guest speaker Phil Hart, winner of multiple David Malin Awards for Astrophotography.

The award ceremony in late October, sponsored by CAASTRO, was hosted by the Melbourne Planetarium at Scienceworks where the winning images were also exhibited for several months. CAASTRO Chief Investigator Prof Rachel Webster took part in the award ceremony and presented the prizes.

Omega Centauri taken by Bruce Drummond, teacher Suzanne Cory High School

Crescent Moon taken by Stephanie Bernard, volunteer and student at UoM

Astronomy Collage by Dale Barry, science coordinator of Gisborne Secondary College

SOCIAL MEDIA & PRESS COVERAGE

CAASTRO's social media is going strong and earning praise

With a research collaboration as spread out as CAASTRO, we have adapted our science communication efforts accordingly and have maintained a very active, reliable, and responsive social media presence. By the end of 2013, CAASTRO was connected to over 500 "followers" on Twitter, 18,000 Facebook users who "like" our page, and 200 "subscribers" to the CAASTRO YouTube channel. These social media accounts are fed with timely information about upcoming talks or interviews of CAASTRO members, print or online articles by or about our members, photos of CAASTRO research or outreach activities, and links to the CAASTRO website for research stories as new CAASTRO publications appear. The YouTube channel is home to CAASTRO's growing wealth of video material (exceeding 100 uploads and 40,000 video views), not only including profiles of the three research themes and a number of seminar recordings, but also our two most active and most dedicated programs. "Pint in the Sky" is a casual pub chat series, led by CAASTRO Affiliates Dr Katie Mack and Dr Alan Duffy at the University of Melbourne. This project came out of the CAASTRO professional training day at The University of Western Australia in November 2012 via the topic "Astrophysics meets YouTube". Since then, eight episodes have been recorded and edited, with the assistance of CAASTRO Education and Outreach Coordinator Dr Wiebke Ebeling, and a further five were produced as part of National Science Week 2012.

We are particularly proud of our most popular influx of videos, the "Video Press Releases" (ViPRs). These short explanatory clips are aimed at a public audience and combine visually appealing animation material with showcasing the CAASTRO researcher on camera or by narration, presenting background information, the scientific method, and real results, as well as their significance with regard to a new publication. In 2013, we produced three such ViPRs to accompany press releases for Dr Mike Childress and colleagues' paper on Supernova 2012fr (June 2013), the High Time Resolution Universe survey team's discovery of four Fast Radio Bursts (July 2013), and Prof Steven Tingay's study on the innovative capability of the Murchison Widefield Array to detect and track space junk (November 2013). In many of our ViPRs, we make use of the high quality animations created for us by Swinburne Astronomy Productions. The CAASTRO social media strategy has received overwhelmingly positive feedback, both from individuals and from other research centres, and the CAASTRO Education and Outreach team has been approached for advice on multiple occasions which is a very encouraging outlook to 2014 and beyond.

International science communication stars tour the Tidbinbilla Tracking Station *Credit: Chris Cassella*

Science communication partnerships for National Science Week 2013

CAASTRO's involvement in National Science Week – the annual celebration of science in Australia – embraced the spirit of science communication through social media. In collaboration with the internet platform ScienceAlert (www.sciencealert.com.au) and the Australian National Centre for the Public Awareness of Science (cpas.anu.edu.au), we invited internationally acclaimed science communicators to Canberra and co-organised an expert panel discussion. Our "Pint in the Sky" hosts Dr Katie Mack and Dr Alan Duffy travelled from Melbourne to meet them for the event, their series' video recordings, and some night sky observing – thanks to a loan from the "Telescopes in Schools" program. We further added to our visitors' experience by lining up a tour of the NASA Deep Space Communication Complex in Tidbinbilla.

CAASTRO in the (Chinese) Classroom
Credit: Lan Lin

CAASTRO/Curtin University Honours student Hannah Feldman testing her MWA 'Teaching Tool'
Credit: Wiebke Ebeling

CAASTRO members in print and online media

The year 2013 saw around 300 articles in newspapers and online resources that featured CAASTRO members with their recent publications or involvement in public debates and events. One such highlight was certainly the 25th anniversary special edition of *The Australian* Magazine that named Prof Brian Schmidt "Person of the Year" for his Nobel Prize winning research on supernovae and the accelerated expansion of the Universe. The launch and commencement of science operations of the Murchison Widefield Array further triggered a flurry of media activity from the middle of the year onwards, fuelled by the CAASTRO press release on the telescope's capability to detect and track space junk. In CAASTRO, we are also fortunate to have members who contribute their own articles and their expert opinion on matters in the public debate. Writing for The Australian, CAASTRO Director Prof Bryan Gaensler argued for a better gender balance in science and Prof Brian Schmidt publicly offered a bet with climate change deniers. In 2013, pieces in The Conversation included Prof Matthew Bailes' explanation of Moore's Law and the demise in alien sightings since widespread use of digital cameras, and his in-depth reflection of his co-authored publication in *Science* that reported the detection of four Fast Radio Bursts of unknown physical origin and their huge potential in "weighing" the Universe.

MENTORING, PROFESSIONAL DEVELOPMENT & SCIENCE EDUCATION

Networking and career advice by CAASTRO Mentors

CAASTRO is very committed to ensure our students and junior academics receive valuable training, gain transferable skills, and advance their careers. To this end, we continue a mentoring program that is designed to provide support and guidance for our younger members by experienced mentors. The nature, frequency, and intensity of the mentoring sessions and activities are up to each mentor-mentee pairing, with the high resolution 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.

Annual training for our members

Focussing on topics of relevance to our members' career paths and to the CAASTRO Education and Outreach program, we organise a Professional Development day every year in conjunction with the CAASTRO Annual Retreat. In 2013, the company Biotext (www.biotext.com.au) provided our participants with training in "Writing clear science". While primarily aimed at grant and job applications, the underlying principles of the training also directly benefit CAASTRO's ongoing efforts to communicate current research results to the public. Since late 2012, the CAASTRO Education and Outreach team has worked with our researchers to summarise their recent published research in short, semi-technical stories that are being published on the CAASTRO website, promoted through CAASTRO social media, and collated in the bi-annual "CAASTRO Reader's Digest" booklets.

Introducing Science Education as a novel CAASTRO research area

One of the most exciting initiatives in 2013 was the expansion of CAASTRO Education and Outreach into a new research area with the supervision of the first Honours student in Science Education. This first project used the Murchison Widefield Array as an exemplar for a real-world application of physical concepts such as electromagnetic radiation and wave interference, as well as an important scientific and economic asset of Australia, and Western Australia in particular. Curtin University student Hannah Feldman developed a hands-on radio astronomy "Teaching Tool" for High School students and also collaborated with the software programming team at Quantum Victoria to create a space game, featuring the capabilities of the MWA and its key science targets, such as pulsars and space debris. The pilot of the hands-on tool has since been "field-tested" at the Community Science Fair at the Gravity Discovery Centre in Gingin, Western Australia, and has seamlessly transitioned into a summer project for Curtin University student Seonaid Rodgers to improve performance of the tool and design classroom activities. The CAASTRO Education and Outreach team, Dr Wiebke Ebeling and Prof Steven Tingay, will continue to recruit students to this new research area and offer Science Education projects.

CAASTRO LOCATIONS

MWA Melbourne Busy Week
Credit: Emil Lenc

International Centre for
Radio Astronomy Research

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 Deputy 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 Cathyrn 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.

ICRAR
Credit: ICRAR

Curtin University

CAASTRO AT CURTIN UNIVERSITY

The Curtin Institute of Radio Astronomy employs ten CAASTRO academics who contribute to "The Evolving Universe" and "The Dynamic Universe" research themes, as well as to CAASTRO's Education and Outreach program. Professor Steven Tingay is the Curtin node leader and member of the CAASTRO Executive with Education and Outreach in his portfolio. In 2013, the team was joined by five Curtin Honours students with projects across the three themes and also by Dr Paul Hancock who moved from the CAASTRO headquarters in Sydney to Perth as a new Curtin Research Fellow.

The year 2013 marked an important milestone for the team at Curtin, being the managing organisation of the Murchison Widefield Array (MWA), with the official launch of this low frequency precursor instrument for the Square Kilometre Array and commencement of science operations. Since then, several petabytes of data have flown into the supercomputers at the also recently launched Pawsey Centre in Perth. The CAASTRO team at Curtin has not only made use of these data to search for pulsars and other transients, but have also used their detailed knowledge of the instrument to predict the detection rate of Fast Radio Bursts. Curtin-based CAASTRO staff have also developed new data processing algorithms to search MWA data for the faint Epoch of Reionisation signal. Curtin also hosted the very successful "The Ephemeral Universe" CAASTRO workshop in November 2013, bringing together many CAASTRO members and international experts on transients and providing a superb platform to debate the mysterious origin of Fast Radio Bursts. Discussions were exceptionally lively and fuelled by the recent publication in *Science* by the High Time Resolution Universe team. The workshop was organised by CAASTRO Associate Investigator Dr Jean-Pierre Macquart and his fellow CAASTRO members on the committee Dr Ramesh Bhat, Dr Wiebke Ebeling, and Dr Stephen Ord. Curtin was fortunate to have Dr Jason Hessels from ASTRON in the Netherlands visit by invitation from CAASTRO, to attend the workshop and participate in a number of fruitful discussions about pulsars and Fast Radio Bursts.

In 2013, research highlights from the CAASTRO team at Curtin included:

- **BIGHORNS**
  As part of this project within "The Evolving Universe" theme, Dr Marcin Sokolowski, Dr Steven Tremblay, and Dr Randall Wayth developed and fine-tuned their antenna pilot system to search for the global signal of the Epoch of Reionisation. The system was deployed and tested in low interference locations in the Western Australian outback during several field trips.
- **Fast Radio Bursts**
  Curtin has emerged as a front-runner in the hunt for Fast Radio Bursts, combining expertise in theoretical astrophysicists from Dr Cathryn Trott and Dr Jean-Pierre Macquart with Dr Ramesh Bhat's participation in the High Time Resolution Universe survey and the new capabilities of the MWA. Under the supervision of Dr Ramesh Bhat, Dr Stephen Ord, Dr Steven Tremblay, and Prof Steven Tingay, CAASTRO PhD student Samuel Oronsaye has commenced observations and started developing data analysis routines to capture and characterise more of these bursts.
- **Science Education**
  As of 2013, the CAASTRO Education and Outreach team, Dr Wiebke Ebeling and Prof Steven Tingay, offers research projects in Science Education at Curtin. Honours student Hannah Feldman successfully completed her degree, having created a hands-on radio astronomy "teaching tool" for High Schools and also collaborated with Quantum Victoria in Melbourne for the development of a computer game based on the MWA. This new research field has since continued to attract Curtin students.
- **Space Junk**
  Following the discovery by CAASTRO PhD student Ben McKinley at the Australian National University that the MWA could image the Moon using reflected FM radio signals, Curtin node leader Prof Steven Tingay led a feasibility study into the MWA's capabilities to detect and track pieces of space debris. The results of this study not only show the potential of the MWA in making a valuable contribution to space situational awareness, the story also attracted substantial media attention and considerable interest from defence organisations and the aerospace industry.

CAASTRO Curtin University Team members

Prof Steven Tingay

CAASTRO Chief Investigator, Curtin Node Leader, Executive Member, Theme 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 MWA. A significant new activity that Tingay contributed to in 2013 was outreach-based research projects for Curtin students, with the graduation of an Honours student. Tingay's involvement in Epoch of Reionisation research, both via global signal and power spectrum techniques, continues via CAASTRO. A major milestone in 2013 was the operational launch of the MWA, an instrument that fuels a significant percentage of CAASTRO's research portfolio.

Dr Ramesh Bhat

CAASTRO Associate Investigator
Theme: Dynamic

Bhat's research continued to focus on areas of observational pulsar astronomy and the transient radio Universe. Among the highlights from 2013 are the completion of a major undertaking that demonstrated the power of interferometric arrays such as the Indian GMRT for detection and localisation of fast radio transients and the discovery of a population of Fast Radio Bursts from the High Time Resolution Universe survey at Parkes. He is involved in the development of high time resolution science capability for the MWA and initiated early science to showcase this new capability.

Dr Jean-Pierre Macquart

CAASTRO Associate Investigator
Theme: Dynamic

In 2013, Macquart worked on the scattering of both cosmological transients and pulsars. One focus was theoretical work on the scattering of the radio waves from transients located at cosmological distances, particularly the bright Fast Radio Bursts detected at the Parkes radio telescope. This work aims to provide a means of extracting information about the Inter-Galactic Medium on scales down to 10^8 m. Another highlight involved collaboration with CAASTRO Partner Investigator Prof Ue-Li Pen to use interstellar scintillation to resolve the magnetosphere of a pulsar on a scale of only 50 pico-arcseconds, the highest resolution yet attained by any astrophysical technique.

Dr Stephen Ord

CAASTRO Associate Investigator
Theme: Dynamic

During 2013, Ord continued development of the high time resolution capability of the MWA and the team of Ord, Tremblay, Oronsaye, Bhat, and Tingay have begun an innovative program to use the MWA as a Fast Radio Burst detector. The MWA now has a real time transient detection pipeline under development, and the offline pulsar detection pipeline continues to evolve. Ord served on the local organising committee of the extremely successful CAASTRO-sponsored "The Ephemeral Universe" workshop at Curtin, and is devoting considerable time to the design of the Correlator for the SKA.

Dr Randall Wayth

CAASTRO Associate Investigator
Theme: Evolving

Wayth is a Curtin Senior Research Fellow, MWA staff scientist, project manager for the CAASTRO-supported BIGHORNS EoR Global Signal project, and team leader for the MWA GLEAM sky survey. Wayth supervises CAASTRO Masters student Mehran Mossammaparast and supervised 2013 CAASTRO Honours Student Kim Steele. In addition to the GLEAM survey, Wayth works with several CAASTRO members on the MWA Epoch of Reionisation key science program.

Dr Wiebke Ebeling

CAASTRO Education & Outreach Coordinator
Theme: Education & Outreach

Ebeling is responsible for the support of all CAASTRO outreach activities and program collaborations, maintenance of the CAASTRO website and social media channels, production of new contents and coordination of input from CAASTRO members, compilation and distribution of the biannual "CAASTRO Reader's Digest" booklet, professional development for CAASTRO students and staff, and partnerships with outreach collaborators. In 2013, Ebeling also established a new research field at CIRA and supervised the first CAASTRO Education & Outreach Honours student to develop a hands-on radio astronomy education tool. She further co-authored all CAASTRO press releases, three of which were accompanied by a short explanatory video.

Ms Hannah Feldman

CAASTRO Honours Student
Theme: Education & Outreach

Feldman was the first research student in the newly created field of Science Education at the Curtin Institute of Radio Astronomy, under the supervision of CAASTRO's Education and Outreach team Prof Tingay and Dr Ebeling. In her project, she evaluated the feasibility of custom-designing and implementing hands-on radio astronomy activities into the Australian Curriculum. She developed a "teaching tool" and also collaborated with the team at Quantum Victoria to create a game, both based on the Murchison Widefield Array (MWA) and designed for Year 9 High School students.

Mr Cody Gough

CAASTRO Honours Student
Theme: Dynamic

Gough completed his Honours project in 2013 under the supervision of Dr Ramesh Bhat. This project focused on six years of new observations of PSR J1141-6545, a highly gravitationally asymmetric system which provides a rare opportunity for the testing of alternative theories of gravity including scalar tensor theories, taken with the Parkes 64m radio telescope using the new state-of-the-art CASPSR backend. Pulse arrival times were produced from this data and analysed using the TEMPO2 software package to improve current measurements of the Keplerian and post-Keplerian parameters for the system.

Dr Paul Hancock

CAASTRO Affiliate
Theme: Dynamic

Hancock has taken the idea of image stacking and applied it to transient radio phenomena to provide insights into the nature of type Ia supernovae and long Gamma-ray bursts. He is one of the main contributors to the VAST pipeline – an analysis and visualisation tool designed to detect and classify variable and transient radio sources from the latest generation of radio surveys. Hancock has a continued interest in supernovae and gamma-ray bursts and often forms international collaborations to investigate rare and interesting events using the Australia Telescope Compact Array. He is currently using the VAST pipeline to process data from the MWA in order to detect various signatures of variability. One such signature is the scintillation of distant galaxies that occurs as their light passes through the interstellar medium of the Milky Way.

Mr Luke Horsley

CAASTRO Honours Student
Theme: Evolving

After helping to construct and commission the Murchison Widefield Array (MWA), Horsley analysed some of the first data from the instrument in an effort to characterise the ionosphere above the observatory. Under the supervision of Curtin's Dr Natasha Hurley-Walker and Prof Steven Tingay, he analysed four nights of data, in a range of ionospheric conditions and over several frequency bands. He was able to describe the magnitude and fluctuation timescale of the ionsopheric shifts and determine the optimum time of night for future observers.

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 is working towards finishing his thesis soon.

Mr Samuel Oronsaye

CAASTRO PhD Student
Theme: Dynamic

Oronsaye started his PhD project in 2012 and applied pulsar software packages to the search for pulsars in data from the 32-tile MWA with the incoherent beam. In 2013, he also performed searches for Fast Radio Burst and pulsars using the incoherent beam and the full 128-tile system, with results currently in preparation for publication in 2014.

Mr Jarrod Ramsdale

CAASTRO Honours Student
Theme: Dynamic

Ramsdale investigated the micro-arcsecond scale polarisation structure associated with the emission from the base of jet emanating from the supermassive black hole of a distant radio galaxy. The radio emission from this galaxy exhibits intra-day variability, caused by scattering in the local interstellar medium of the Milky Way galaxy. By examining the power spectra

of the polarisation variations and through a detailed understanding of how small-scale structure influences the variability properties of a scintillating source, Ramsdale was able to extract information about the structure of this source on scales down to ~10 micro-arcseconds.

Dr Marcin Sokolowski

CAASTRO Postdoctoral Researcher
Theme: Evolving

In early 2013, Sokolowski mainly worked on understanding the response of the BIGHORNS system, with the primary focus on improving the signal calibration and the system's stability. He also worked on sky signal modelling in order to generate model data samples corresponding to real data collected in 2012 and 2013. Sokolowski was awarded NCI computing time through CAASTRO, which will aid the modelling. In the second half of 2013, he organised two trips with the fully mobile BIGHORNS system to Eyre Bird Observatory, a remote site in WA. His summer student Morgan Lewis accompanied him on his last trip, when the system was run from the battery allowing on-the-fly re-charging without interrupting data collection.

Ms Kim Steele

CAASTRO Honours Student
Theme: Evolving

Steele was part of the "Student Army" who helped constructing the 128-tile 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 radio spectrum TN0924-2201. The work confirmed previous results on this source and continues into 2014 with new data from the full MWA.

Dr Steven Tremblay

CAASTRO Postdoctoral Researcher
Theme: Dynamic

In 2013, Tremblay led the commissioning of the Voltage Capture System (VCS) on the MWA. Multiple pulsars, including one millisecond pulsar, were observed with the system as part of the commissioning effort and Tremblay also oversaw the first steps in developing and MWA fast transients search pipeline with these early data. Tremblay is a co-supervisor of CAASTRO PhD student Samuel Oronsaye whose thesis involves searching for pulsars with the MWA and uses the VCS to do so. Additionally, Tremblay worked on the BIGHORNS EOR Global Signal Experiment. This work ranged from continued development of both the analogue and digital components of the data collection system to field trips taking data in remote, RFI quiet locations in Western Australia. Tremblay also continued his appointment as "The Dynamic Universe" Theme Scientist throughout 2013.

Dr Cathryn Trott

CAASTRO Postdoctoral Researcher
Theme: Dynamic, Evolving

As part of the Dynamic Theme, Trott contributed to a range of projects predicting the rate 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'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. She has also derived a framework for understanding the noise properties of EoR datasets with low-frequency radio interferometers, contributing to the optimal design of EoR experiments. She continued her collaborative projects in 2013, working with medical physicists from Harvard to evaluate the utility of new medical imaging techniques for estimating the size and location of tumours.

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.

Mrs Roselina Stone

Administrative Assistant

Stone assisted the Curtin node administration and provided administrative support to the CAASTRO team at Curtin.

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieve International Excellence

CAASTRO AT THE UNIVERSITY OF WESTERN AUSTRALIA (UWA)

The CAASTRO node at the University of Western Australia is embedded in the UWA node of ICRAR, which has seven tenured research staff, a further 32 staff involved in astrophysics research, ICT, outreach and administration; and a cohort of around 20 PhD students. ICRAR/UWA itself is associated with the School of Physics which owns the 1-m Zadko optical telescope at Gingin and hosts a Gravity Wave group and a Frequency and Quantum Metrology group. The School of Physics building also hosts iVEC@UWA which is the home of the Fornax supercomputer. The Pawsey Centre is run by iVEC which is a joint venture between CSIRO and WA Universities.

UWA node members during 2013 were: Deputy Director and Node Director Lister Staveley-Smith; Associate Investigators Chris Power and Martin Meyer; postdoctoral scientists Anna Kapinska, Se-Heon Oh and Chris Springob; PhD students Tao Hong, Scott Meyer, Steven Murray, Paul Scott-Taylor and Morag Scrimgeour; Affiliates Danail Obreschkow, Weiguang Cui and Richard Newton; and Administrative Officer Clare Peter.

Major contributions to the Dynamic science theme have been:

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

- Several papers, including new ALMA results, have been published by Staveley-Smith, Gaensler, ICRAR student Giovanna Zanardo and international collaborators on the continuing evolution of Supernova 1987A. Of recent interest is the large amount of dust discovered in the ejecta.
- Staveley-Smith and Danny Price have assisted Swinburne CAASTRO researchers (Bailes et al.) in the final commissioning of the Parkes HIPSR spectrometer which is now the primary backend for pulsar and FRB searches (as well as HI experiments).

Major contributions to the Evolving science theme have been:

- Meyer, Staveley-Smith and ICRAR Ph.D student Delhaize have published an accurate analysis of cosmic gas evolution over the past billion years using the technique of 'stacking'. This method allows higher redshifts to be explored than previously possible.
- Several million hours of supercomputing time were awarded in 2013 to the Survey Simulations PipeLine (SSimPL) collaboration, of which Power is a founding member, to model large-scale cosmic structure and galaxy formation and evolution.
- The theoretical and observational research activity on angular momentum has had its first publication accepted on the mass-spin-morphology relation in spiral galaxies (Obreschkow & Glazebrook). This work suggests that the historical classification of galaxies by Hubble-type can be reduced to a more physically motivated classification by angular momentum. This work builds towards the analysis of SAMI data in 2014/15.
- Oh has led the development of a robust pipeline for the automated study of galaxy velocity fields and rotation curves. The principal use will be for the ASKAP Wallaby and Dingo surveys, but is currently being tested on HI data from existing galaxy surveys.
- Staveley-Smith with Duffy, partner investigator Subrahmanyan, ICRAR PhD student Malarecki and other collaborators have used giant radio galaxies as probes of the pressure of the interstellar medium. They found that pressures in the cosmic web were much lower than implied by X-ray observations, and consistent with IGM particle overdensities of 50 to 100.
- Several studies by Staveley-Smith, Gaensler and S-PASS principal investigator Ettore Carretti have used the new Parkes S-PASS survey to study continuum and polarised emission from the Galactic Centre, the Galaxy, and clusters of galaxies. A *Nature* paper in early 2013 announced the discovery of the polarised radio counterpart to the so-called Fermi Bubbles which are energised by outflows from the Galactic Centre.

Major contributions to the Dark science theme have been:

- Hong, Springob, Staveley-Smith and collaborators have completed a preliminary analysis of the 2MASS Tully-Fisher Survey (2MTF) sample. Peculiar velocities for around 2000 galaxies have been derived, and bias corrections have been applied.

CAASTRO UWA team members

They have used this sample to measure the bulk flow of the local Universe.

- Springob and collaborators have investigated the cosmography of the 6dF Galaxy Survey peculiar velocities, and compared the observed peculiar velocities to those predicted by models. The bulk flow of the local Universe has been measured with this sample.
- Detailed comparisons of the measured velocity function from HIPASS against theoretical models of galaxy evolution, led by Obreschkow, fully supports the favoured cosmological model (ΛCDM) within the observational uncertainties.
- Murray, Power and collaborator Robotham have analysed the impact of increasingly accurate measurements of the cosmological parameters on our knowledge of the dark matter halo mass function.
- Oh and collaborators have found a core-like dark matter distribution in the galaxies from the VLA LITTLE THINGS HI galaxy survey. A shallow inner density slope of $\alpha \approx -0.3$ is consistent with the previous results found in low surface brightness galaxies in the Local Group, significantly deviating from the cusp-like dark matter distribution ($\alpha \approx -1.0$) predicted from no-baryon ΛCDM simulations. Instead, they are more in line with the shallower slopes found in the ΛCDM smoothed-particle-hydrodynamics simulations of dwarf galaxies in which the effect of baryonic feedback processes is included.
- PhD student Scrimgeour submitted her PhD thesis containing an analysis of the homogeneity of the Universe using WiggleZ data, a measurement of bulk flow using 6dFGS data, and a simulation of the accuracy of the SkyMapper supernova survey in measuring peculiar velocities.

Future goals

Overall CAASTRO Research goals for the next year at the UWA node include:

- Publish 2MTF bulk flow results, and make detailed comparison between observed peculiar velocity field and models drawn from redshift surveys.
- 6dFGS: publish velocity field cosmography results.
- Work with the TAIPAN collaboration to determine the source selection criteria for the TAIPAN survey.
- Development of theoretical models of galaxy evolution that explicitly account for the key role of the kinematic state of galaxies. These models will contribute to the analysis of SAMI galaxies.
- Commence modelling the synchrotron cosmic web and predicting optimal survey strategies for the detection of missing baryons.
- Estimating the sensitivity of galaxy formation to underlying cosmology, for a range of cosmological models - extending from fiducial ΛCDM, to modified gravity, coupled dark matter and dark energy, to exotic dark energy.
- Deployment of a pipeline for the creation of synthetic galaxy surveys, focussing on future cold gas and X-ray surveys.
- Ensure the success of the GLEAM survey and contribute to the ongoing data reduction and analysis tasks.
- Ramp up reduction and analysis of high-redshift HI data taken in WiggleZ fields, using the technique of intensity mapping.
- Lead analysis of a stacking analysis of HI data from a JVLA survey in the GAMA regions.
- Prepare for the analysis of ASKAP Early Science HI data.
- Complete the first analysis of HI stacking and the Tully-Fisher relation using data from HIPASS

Professor Lister Staveley-Smith

CAASTRO Deputy Director
Themes: Evolving and Dark

Staveley-Smith is Node Director and leads the 2MTF project under the Dark Theme and the Wallaby/Dingo project under the Evolving Theme. Both projects are international collaborations and both have had the strong involvement of PhD students as well as our CAASTRO-funded postdoctoral scientists. Staveley-Smith is also coordinator of the MWA Galactic and Extragalactic science team which has been awarded 254 hrs of observing time for an all-sky continuum survey.

Associate Professor Martin Meyer

CAASTRO Associate Investigator
Themes: Evolving

Meyer's leadership role in the DINGO survey has seen him contribute to projects to stack HI data at moderate redshifts with existing telescopes such as Parkes and the VLA. Studies of the cosmic HI density and the global Tully-Fisher relation are underway with PhD students.

Associate Professor Chris Power

CAASTRO Associate Investigator
Themes: Evolving and Dark

Power has continued his work with CAASTRO investigators Kim and Wyithe at the University of Melbourne and co-investigators at Durham University and ESO Garching to evaluate how forthcoming HI surveys can be used to test theoretical models of galaxy formation, and with CAASTRO investigator Croom on galaxy models for SAMI. He is working with: CAASTRO PhD student Murray to explore how semi-empirical models of galaxy formation are sensitive to assumptions about underlying cosmology; CAASTRO PhD student Scott-Taylor to deploy an automated pipeline for creating synthetic galaxy surveys using both full N-body and approximate schemes; CAASTRO affiliate Newton on simulating the synchrotron cosmic web; and CAASTRO affiliate Cui on modelling structure formation in non-standard cosmologies.

Dr Weiguang Cui

CAASTRO Affiliate
Theme: Evolving and Dark

Cui will work on the cosmic web, using the comic web identification codes: DISPERSE, Vweb. He will work with Gaensler, focusing on predictions of cosmic web properties from simulations and comparing with observation results. He will also work on modified gravity/dark energy simulations. Cui has a modified Gadget code to undertake cosmological simulations. He is applying a new minimalist modified gravity (gamma) model to the new updated Gadget-3 code. In collaboration, he will run cosmological simulations under modified gravity and alternative dark energy models, and document the changes in halo properties and merger histories. Cui will also investigate the cosmic web in those models to examine any major differences with the standard ΛCDM model.

Mr Tao Hong

CAASTRO Postgraduate Student
Theme: Dark

Hong is enrolled at the National Astronomical Observatories, Chinese Academy of Sciences. In an agreement between NAOC and UWA, he spends 50% of his time in Australia to work on the 2MASS Tully-Fisher project (2MTF) as a CAASTRO student. His supervisors are Staveley-Smith and JinLin Han, and he also works closely with Springob and other researchers at the AAO, CSIRO and Monash University. Using the 2MTF data, he is now working on building peculiar velocity field and analysing the bulk flow in the local Universe.

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 MWA All-Sky Survey (GLEAM). The survey is to be completed in mid-2014. 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 continues also work on the LOFAR Deep Sky Surveys which she joined in late 2012

Mr Scott Meyer

CAASTRO Postgraduate 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.

Mr Steven Murray

CAASTRO Postgraduate Student
Theme: Evolving and Dark

Murray has been investigating Dark Matter haloes with supervisors Power and Aaron Robotham. This investigation has had a two-pronged focus. Firstly on developing non-parametric methods of describing the global shape of a dark matter halo, using an adapted two-point correlation function, and secondly developing an interactive web-application which calculates the Halo Mass Function for an input cosmology. Murray intends to extend this application to more general Halo Model calculations in the near future, as well as alternative cosmologies.

Dr Richard Newton

CAASTRO Affiliate
Theme: Evolving and Dark

Newton joined ICRAR and CAASTRO at UWA from the Jodrell Bank Centre for Astrophysics to take up the Jim Buckee Fellowship in November of this year. Since this time he has improved and made public a galaxy initial conditions generating code, begun collaborations with CAASTRO members, and been awarded 1.1 million hours of supercomputing time. He has also written an early version of the mock observations code to be used by the SSimPL collaboration.

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

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 tested using both simulated synthetic HI data cubes and those of the observed galaxies from ATCA LVHIS and VLA THINGS nearby HI galaxy surveys. In addition, he has finished the mass modelling of 26 dwarf galaxies from VLA LITTLE THINGS HI galaxy survey in order to examine the dark matter distribution in the galaxies, addressing the 'cusp/core' problem in ΛCDM simulations.

Ms Morag Scrimgeour

CAASTRO Postgraduate Student
Theme: Dark

Scrimgeour worked on dark matter and cosmology. During her time with CAASTRO she was working on new analysis techniques for peculiar velocities and simulations of the SkyMapper survey supernova survey. Her supervisors were Staveley-Smith and Davis, and she worked closely with CAASTRO CIs Blake and Schmidt. Scrimgeour submitted her PhD thesis in late 2013.

Dr Paul Scott-Taylor

CAASTRO Postgraduate Student
Theme: Evolving and Dark

Scott-Taylor has been investigating the formation and evolution of galaxies using simulation models with supervisors Power and Obreschow, 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 Galacticus software. He 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 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. He has served as Dark Theme Scientist since 2012, but stepped down from that role at the end of 2013.

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 COO. She works alongside the ICRAR UWA administration team.

THE UNIVERSITY OF SYDNEY

CAASTRO AT THE UNIVERSITY OF SYDNEY

The Sydney node of CAASTRO is housed within the Sydney Institute for Astronomy (SIfA), which is part of the School of Physics within The University of Sydney. SIfA has had a long heritage of astronomical instrumentation and sky surveys, and currently pursues a vigorous program of hardware and software development. This expertise has provided a key foundation for our contributions to CAASTRO.

Within the Evolving Universe theme, Sydney is involved in three main areas:

- An enormous new survey of star formation and galaxy evolution over the local volume on the Anglo-Australian Telescope, using the new multi-object integral field spectrograph technology that Sydney and AAO have together developed (Allen, Bland-Hawthorn, Bloom, Bryant, Croom, Fogarty, Richards, Schaefer, Scott).
- Precision calibration of low-frequency radio data from the Murchison Widefield Array (MWA), with particular focuses on the low-frequency turnover in extragalactic sources, and on polarisation measurements and foreground removal as required for studying the Epoch of Reionisation (Callingham, Farrell, Gaensler, Lenc)
- Wide-field surveys of 21cm hydrogen absorption as a means of probing gas in galaxies over a much wider range of cosmic times than has previously been possible. This will culminate in the "First Large Absorption Survey in HI" (FLASH), to be undertaken using ASKAP (Allison, Curran, Glowacki, Reeves, Sadler).

Sydney is also making major contributions to the Dynamic Universe theme:

- Fast new algorithms for reliably finding variable and transient sources in wide-field radio maps, robustly measuring their properties and then classifying them into pre-defined categories, all in near real-time. This also serves as the basis of a data pipeline for the forthcoming Variable and Slow Transients (VAST) survey on ASKAP (Bell, Gaensler, Hancock, Murphy).
- Analysis of large archival radio, optical and X-ray data sets, to identify new, rare, classes of transient sources (Adermann, Bell, Burlon, Farrell, Gaensler, Hancock, Madsen, Murphy, Musaeva)
- New surveys for radio variability at low frequencies, using the unique wide-field capabilities of the MWA and of the SKA Molonglo Prototype (SKAMP) (Bell, Campbell-Wilson, Gaensler, Green, Hancock, Murphy)

The overall CAASTRO team at Sydney had grown to 32 people by the end of 2013, including 12 postdocs and 10 students. We also hosted many visitors to CAASTRO throughout the year, including Dr Gianni Bernardi (SKA South Africa, April 2013), Prof Luciano Rezzolla (Institute of Theoretical Physics, July 2013), Ms Daniela Huppenkothen (University of Amsterdam, July 2013), Dr Natasha Hurley-Walker (Curtin University, July 2013 and December 2013), Prof Gregg Hallinan (CalTech, September 2013), Prof Roger Davies (University of Oxford, September 2013), Prof Vernesa Smolčić (University of Zagreb, November-December 2013), Prof Snežana Stanimirovic (University of Wisconsin, December 2013) and Prof Stephen Ng (Hong Kong University, December 2013).

Our research highlights for the year included:

- The first search for transient and variable radio sources using the MWA. We used the MWA 32-tile prototype at 154 MHz to obtain 51 images over 2010 and 2011 covering a field-of-view of 1430 deg^2 centred on Hydra A. The mean cadence of the observations was 26 min and there was additional temporal information on day and year time-scales. We explored the variability of a sample of 105 low-frequency radio sources within the field. Four bright ($S > 6$ janskys) candidate variable radio sources were identified that displayed low levels of short time-scale variability (26 min). We concluded that this variability is likely caused by simplifications in the calibration strategy or ionospheric effects. However, on a time-scale of 1 year we found two sources that show significant variability. We attributed this variability to either refractive scintillation or intrinsic variability. No radio transients were identified and we placed an upper limit on the surface density of such sources $\rho < 7.5 \times 10^{-5}$ deg^{-2} with flux densities >5.5 janskys, and characteristic time-scales of both 26 min and 1 year.
- A detailed study of focal ratio degradation in fused hexabundles, as are being used for the SAMI survey. We characterised the performance of hexabundles with different cladding thicknesses and compared them to that of the same type of bare fibre, across the range of fill fractions and input f-ratios likely in an integral field unit instrument.

CAASTRO University of Sydney team members

We tested hexabundles with both 7 and 61 cores for focal ratio degradation (FRD), throughput and cross-talk when fed with inputs from F/3.4 to >F/8. As expected, we found that the FRD improves as the input focal ratio decreases; specifically, the FRD and throughput of the cores in the hexabundles match the performance of single fibres of the same material at low input f-ratios. The performance results presented can be used to set a limit on the f-ratio of a system based on the maximum loss allowable for a planned instrument. Our results confirm that hexabundles are a successful alternative for fibre imaging devices for multi-object spectroscopy on wide-field telescopes; this has prompted us to further develop hexabundle designs with hexagonal packing and square cores.

- A new precision, multi-epoch photometric catalogue that spans 60 years by combining the US Naval Observatory-B (USNO-B) and Sloan Digital Sky Survey (SDSS) Data Release 9 (DR9) catalogues. We recalibrated the photometry of the original USNO-B catalogue and created a catalogue with two epochs of photometry in up to five different bands for 43,647,887 optical point sources that lie in the DR9 footprint of the northern sky. The recalibrated objects span a magnitude range $14 \leq m \leq 20$ and are accurate to ≈ 0.1 mag. We minimised the presence of spurious objects and those with inaccurate magnitudes by identifying and removing several sources of systematic errors in the two originating catalogues, with a focus on spurious objects that exhibit large apparent magnitude variations. After accounting for these effects, we found $\approx 250{,}000$ stars and quasars that show significant ($\geq 4\sigma$) changes in brightness between the USNO-B and SDSS DR9 epochs.
- A new view of the HI column density - radio source size anti-correlation in compact radio sources. Existing studies of the atomic hydrogen gas content in distant galaxies, through the absorption of the 21-cm line, often infer that the total column density, N_{HI}, is anti-correlated with the linear extent of the background radio source, d_{em}. We investigated this interpretation, by dissecting the various parameters from which N_{HI} is derived, and find that the relationship is driven primarily by the observed optical depth, τ_{obs}, which, for a given absorber size, is anti-correlated with d_{em}. Therefore, the inferred N_{HI} - d_{em} anti-correlation is merely the consequence of geometry, in conjunction with the assumption of a common spin temperature/covering factor ratio for each member of the sample, an assumption for which there is scant observational justification. While geometry can explain the observed correlation, many radio sources comprise two radio lobes and so we modeled the projected area of a two-component emitter intercepted by a foreground absorber. From this, the observed τ_{obs}-d_{em} relationship is best reproduced through models that approximate either of the two Fanaroff and Riley classifications, although the observed scatter in the sample cannot be duplicated using a single deprojected radio source size. Furthermore, the trend is best reproduced using an absorber of diameter ~100-1000 parsecs which is also the range of values of d_{em} at which the 21-cm detection rate peaks. This may indicate that this is the characteristic linear size of the absorbing gas structure.

Our busy outreach and education schedule continued throughout 2013. Our main focus continued to be "CAASTRO in the Classroom" (CitC), a program led by Jamie Farnes and Shane O'Sullivan in which we deliver astronomy content to high schools across New South Wales via video-conferencing. More than 400 students from 30 different schools participated in 14 separate CitC events throughout the year. We also held our first ever CitC event in China, in which more than 80 students and teachers from Beijing Huijia Private School, Hangzhou Senior High School and Akesu High School all enthusiastically participated via video-conference in a discussion about the origin and future of the Universe.

Throughout 2013, CAASTRO continued to be based in a dedicated refurbished building in Redfern, in which we have made heavy use of dedicated meeting rooms, video-conferencing facilities, break-out areas and visitor space. We hosted a variety of events and workshops at CAASTRO HQ throughout 2013, including "Galaxy Velocity Fields from Large HI and Optical Surveys" (June 2013), "How To Be an Effective Referee" (November 2013) and "Exploring the Radio Transient Sky" (December 2013). Construction is now underway on our exciting new building on The University of Sydney's main campus – we hope to be able to take up residence there in another 12-18 months.

The University of Sydney hosts CAASTRO's main administrative office, which in 2013 consisted of Kate Gunn (Chief Operating Officer), Debra Gooley (finance), Michelle Sullivan (executive support) and Kylie Williams (events & communications). 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. Advanced planning is already underway for CAASTRO's annual scientific conferences in 2014 and 2015, and for our next annual retreat, planned for Twin Waters, Queensland, in November 2013.

Professor Bryan Gaensler

CAASTRO Director
Themes: Dynamic and Evolving

Gaensler leads research activities in the Dynamic Universe theme at the University of Sydney. In 2013, he worked on searches for variable and transient sources with the MWA, on all-sky optical variability on 50-year time scales, and on radio and millimetre observations of the rapidly brightening remnant of Supernova 1987A. In 2014, he plans to focus on new continuum polarimetry surveys with the MWA, Parkes and ASKAP, and on active galaxies as probes of their environments.

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. 2013 has been a spectacular year, which started with the successful commissioning of the upgraded SAMI instrument. Over 150 nights of telescope time were awarded to the survey, starting in 2013, so the SAMI Galaxy Survey is now fully up and running. 2014 looks to be a year of exciting science results published by the SAMI team, on topics including the role of environment in star formation, examining the role of dynamical disturbance and studying the distribution of stellar angular momentum.

Professor Elaine Sadler

CAASTRO Chief Investigator
Theme: Evolving

In 2013 Sadler has been working with Allison, Curran and Reeves on the identification and study of redshifted 21cm HI absorption in nearby galaxies. Using the new tools and techniques developed for the forthcoming ASKAP FLASH survey, a blind all-sky HI absorption-line survey at redshift $0 < z < 1$, they have made a range of discoveries including the detection of very weak, broad HI absorption in a young radio galaxy. In 2014 they will continue work on these nearby galaxies, and also begin analysis of the first test data from ASKAP.

Professor Anne Green

CAASTRO Affiliate
Themes: Dynamic, Evolving

Green leads the upgrade to the capabilities of the Molonglo telescope. In 2013 she worked on implementing to a new system to enable fast transient detection and effective mitigation of radio frequency interference. In 2014, she plans to focus on deep imaging and spectroscopy projects and early searches for transient sources at cosmological distances.

Ms Eromanga Adermann

CAASTRO Honours Student
Evolving, Dynamic

Adermann completed her BSc (Hons) degree in physics at the University of Sydney in 2013. She worked with Sean Farrell and Anne Green on the characterisation of ultra-luminous X-ray sources (ULXs), which are extra-galactic non-nuclear point sources with X-ray luminosities in excess of the Eddington limit for a 10 solar mass black hole. ULXs are believed to be either stellar mass black holes accreting at super-Eddington rates or active intermediate mass black holes.

Dr James Allen

Super Science Fellow, CAASTRO Affiliate
Theme: Evolving

Allen has worked with other SAMI team members to establish the data reduction pipeline that is now being used to process all SAMI data. He took part in observing for the SAMI survey at the Anglo-Australian Telescope, and has begun analysis of the distribution of star formation in cluster galaxies.

Dr James Allison

Super Science Fellow, 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. In 2013 his research focused on the detection of HI absorption-lines in nearby radio-loud galaxies in order to study the role of neutral gas in fuelling active galactic nuclei. In an extensive search of over 200 nearby radio galaxies, using archival all-sky data from HIPASS, Allison found a possible link between high column densities of HI and H_20 megamasers in these systems. Plans for 2014 include an Australia Telescope Compact Array project to explore this HI - H_20 relationship further, and preparation for an ASKAP Early Science HI absorption-line survey.

Dr Martin Bell

CAASTRO Postdoctoral Researcher
Theme: Dynamic

In 2013 Bell focussed on commissioning and conducting the first surveys for low frequency transient and variable radio sources with the Murchison Widefield Array (MWA) telescope. Bell is principal investigator of the "Radio Sky Monitor Survey" which aims to survey almost the entire Southern hemisphere multiple times at low frequencies, on timescales of one month. In 2014

the survey is well underway with the first six months of data already collected. The science papers from this survey are starting to take shape and potentially the detection of new and exciting astronomical objects is on the horizon.

Professor Joss Bland-Hawthorn

CAASTRO Associate Investigator
Theme: Evolving

Bland-Hawthorn leads the development of new survey instruments and their associated science cases for the Anglo-Australian Telescope. These include (a) the SAMI 13-bundle spectrograph; (b) the Hector 100-bundle spectrograph; (c) the PRAXIS OH suppression spectrograph. His particular interest is to understand the evolution of galaxies in the context of their environment. As part of this effort, he is a member of the SSimPL consortium to carry out massive CDM+hydro simulations of how galaxies get their gas over a cosmological volume. He is a member of the GASKAP survey team that targets gas in the Galactic halo, and a member of the GAMA and CALIFA galaxy survey teams.

Ms Jessica Bloom

PhD Student
Themes: Evolving, Dark

Bloom's focus is identifying and classifying mergers and other kinematic anomalies in the SAMI Galaxy Sample. In 2013, she worked on developing tools to perform this analysis. It is hoped that the results of this work will help shed light on the importance of mergers in galaxy evolution.

Dr Julia Bryant

CAASTRO Research Fellow
Theme: Evolving

Bryant is a member of the SAMI Galaxy Survey team, and is the Chair of the Target Selection Working Group which selects the galaxies to be observed with the survey. Her work in developing the SAMI instrument has led to a recently published paper on the instrumental testing and performance of the SAMI instrument which highlights how the SAMI optical fibre imaging bundles, 'hexabundles', maintain the optical properties of the original fibre from which they are made. Her research on galaxy evolution has focused primarily on the relationship between the SAMI integral field imaging data and the radio properties of the SAMI galaxies. She continues to investigate the physics that drives the correlation between the spatially-resolved star formation rate and radio luminosity, and how it is impacted by galaxy environment and stellar masses.

Dr Davide Burlon

CAASTRO Affiliate
Theme: Dynamic

Burlon works on high-energy emission from black holes. In particular he has tested a link between hard X-rays and high-frequency emission from a large sample of local active galactic nuclei. His other principal contribution to CAASTRO activities is in the study of gamma-ray bursts.

Joe Callingham

CAASTRO Postgraduate Student
CAASTRO Theme: Evolving

Callingham has focussed most of the first year of his PhD on contributing to the all-sky survey being conducted by the Murchison Widefield Array (MWA). In particular, he worked on quality control for the point source catalogue and in studying the spectra of compact steep spectrum and gigahertz-peaked spectrum sources. One pilot source was studied in detail with the MWA to demonstrate the capabilities of the instrument and to reveal new insights into the absorption properties and environments of such sources.

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. The culmination in April was a successful detection of the Vela pulsar using only 1/352 of the telescope. Since this success, system development and receiver construction receivers has taken most of Campbell-Wilson's time. In December 2013, 22 receivers were put in the field and after more work stable interferometeric fringes were obtained. The detection of the pulsar (Vela) and stable fringes on 3C273 show that imaging and pulse timing using the full array will be possible in the near future. Two fruitful weeks were spent in Canada at DRAO measuring small RF losses in materials and developing a well matched wideband antenna which the CHIME team have further developed for radio astronomical applications.

Dr Steve Curran

CAASTRO Research Fellow
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 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), explaining the lack of detection of HI 21-cm absorption in high redshift radio sources. 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

Since joining CAASTRO, Farnes has been organising the 'CAASTRO in the Classroom' program together with Shane O'Sullivan. He's hoping to help reach the project out to even more schools, and many more talks are already being planned throughout 2014.

Dr Sean Farrell

CAASTRO Affiliate
Theme: Dynamic

Farrell's specialisation is X-ray astronomy, focussing 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 2013 he provided support through his expertise in X-ray astronomy to various CAASTRO activities. He also played a role in negotiating the signing of a Memorandum of Understanding between CAASTRO and the German eROSITA consortium, which will provide a pathway through which CAASTRO can gain access to data and expertise from the upcoming eROSITA all-sky X-ray survey.

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). This will be the largest IFS sample ever observed. In 2013 Fogarty worked on developing some of the infrastructure for the survey, including data reduction and analysis software and coordination of the observing effort. She also focussed on an investigation of the evolution of early-type galaxies in clusters as part of the SAMI Pilot Survey. This work will be extended in 2014 using the main SAMI Galaxy Survey observations and investigating both cluster and group environments. Fogarty will assume the role of Evolving Theme Scientist in 2014.

Marcin Glowacki

CAASTRO Honours Student
Theme: Evolving

Glowacki completed an Honours project involving MgII absorption and distant QSOs, with Doctors Steven Curran and James Allison.

Dr Emil Lenc

CAASTRO Postdoctoral Researcher
Theme: Evolving

In 2013, Lenc worked as a commissioning scientist for the Murchison Widefield Array (MWA) and as a Theme Scientist for the CAASTRO Evolving Theme. His main activities involved searching for polarised point-sources as part of an MWA full-sky survey and the imaging of diffuse polarised emission with both MWA survey data and also data from deep MWA fields. As an Evolving Theme Scientist, Lenc liaised with the Theme Leader and Project Leaders to update evolving theme project plans. In 2014, he plans to continue work on a full-sky survey to search for polarised point-sources and to map diffuse polarised emission. He further plans to code and implement polarisation foreground removal within the MWA Epoch of Reionisation pipeline

Ms Kitty Lo

CAASTRO Postgraduate Student
Theme: Dynamic

Lo completed her PhD in 2013 and has moved to the UK. Her project was on radio transients as part of CAASTRO's Dynamic Universe research theme. She worked on automatic classification algorithms for the Variable and Slow Transients (VAST) survey on ASKAP.

Dr Greg Madsen

Senior Research Associate, University of Cambridge
Theme: Dynamic

Madsen joined the Cambridge Astronomy Survey Unit team at the Institute of Astronomy in the UK in early 2013, where he helps run their optical and near infrared data processing centre. His research on optically variable stars and quasars continues. At Cambridge, Madsen's research interests have expanded to include the nature of fast radio bursts and the search for evidence of activity from the Galactic centre black hole.

Dr Tara Murphy

CAASTRO Associate 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 large volumes of data that will be produced by next-generation radio telescopes. In 2014, Murphy plans to use new low frequency data from the MWA to investigate ultra-cool dwarf stars and exoplanets, as well as conducting a blind survey for radio transients.

Ms Aina Musaeva

CAASTRO PhD student
Theme: Evolving

In 2013 Musaeva worked on the search for the intermediate mass black holes (IMBHs) in dwarf galaxies. She compiled a galaxy sample from a catalogue of nearby dwarf galaxies and identified the most promising IMBH candidates by analysing the available X-ray data from Chandra and XMM-Newton archives.

Dr Shane O'Sullivan

Super Science Fellow, CAASTRO Affiliate

In 2013, O'Sullivan published papers on the particle content of the radio galaxy lobes of Centaurus A as well as the first broadband circular polarisation spectrum of an AGN jet. In 2014, O'Sullivan will work on creating a new all-sky catalog of polarised radio sources, characterising their polarisation morphologies and optical host galaxy properties. As a CAASTRO affiliate, he continues as one of the coordinators of the CAASTRO in the Classroom outreach program.

Mr Glen Rees

CAASTRO PhD Student
Theme: Evolving

Rees worked on a short-term CAASTRO project, "Understanding the sub-detection radio sky", which was co-supervised by CSIRO. The aim of this project was to develop new techniques for analysing sub detection sources in radio continuum data by comparing stacked observations of VLA & ATCA observations against complex radio sky simulations such as the S3: Semi-Empirical Extragalactic Simulation developed by the SKA Design Studies team.

Ms Sarah Reeves

CAASTRO PhD Student
Theme: Evolving

Reeves is working on analysing HI observations of nearby galaxies. These observations form important preparation for the First Large Absorption Survey in HI (FLASH), which aims to study galaxy evolution at high redshifts. In 2014 her focus will be on increasing the sample of galaxies studied.

Mr Samuel Richards

CAASTRO PhD Student
Theme: Evolving

In 2013, Richards worked as part of the team that commissioned the SAMI instrument to completion, enabling the start of the SAMI Galaxy Survey. Additional to data reduction pipeline work, Richards used the resulting data from SAMI to test single fibre aperture corrections that are used routinely in large surveys such as GAMA / SDSS. Analysis of such data lead to the finding of a particular dwarf galaxy with a HII region that lies in the top percentile of the HII region luminosity function, a progenitor candidate to better understand massive star cluster formation.

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.

Dr Nicholas Scott

CAASTRO Postdoctoral Researcher
Theme: Evolving

Scott works on the SAMI Galaxy Survey, developing new techniques to analyse spatially resolved spectroscopy of nearby galaxies. His research is focused on measuring the stellar kinematics and stellar populations of galaxies in order to understand how they formed and evolved.

Mr Darshan Thakkar

Digital Engineer
Theme: Dynamic

Thakkar continued the development of the SKAMP hardware correlator before leaving the project early in the year for a position with a defence contractor.

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 the CAASTRO in the Classroom program.

Ms Kylie Williams

CAASTRO Events and Communications Officer

Williams coordinated the regular CAASTRO newsletter and organised various events hosted by CAASTRO around Australia.

THE UNIVERSITY OF MELBOURNE

CAASTRO AT THE UNIVERSITY OF MELBOURNE

The University of Melbourne node of CAASTRO is housed within the School of Physics. The Astrophysics group at Melbourne was founded less than 20 years ago, but has a track-record of excellence in observational and theoretical cosmology, areas which provide the basis for our contributions to CAASTRO.

University of Melbourne researchers are primarily engaged within the Evolving Universe theme of which Professor Stuart Wyithe is lead, with an emphasis on Epoch of Reionisation (EoR) science, including:

- A wide field survey of neutral hydrogen in the high redshift Universe with the Murchison Widefield Array (MWA) of which the University of Melbourne was a founding partner (Wyithe, Webster, Mitchell, Pindor, Procopio, Riding, Line).
- Numerical simulation of the evolution of early galaxies and their interaction with high redshift intergalactic gas (Wyithe, Tescari, Jeeson-Daniel, Bolton, Kim, Katsianis).

The University of Melbourne is also making contributions to the Dark Universe theme:

- The use of Ly-alpha in absorption and emission to study baryonic acoustic oscillations at high redshift using the next generation of widefield spectroscopic surveys (Wyithe, Bolton, Greig, Jeeson-Daniel).

2013 saw activity at Melbourne in all of these areas. The CAASTRO team numbered 21 people this year, including 4 postdocs, 6 PhD students, and a further 5 affiliated postdocs.

Summary of this year's research highlights

Understanding the epoch of reionisation and the properties of the first galaxies represent important goals for modern cosmology. The structure of reionisation is known to be sensitive to the astrophysical properties of the galaxies that drove reionisation. Thus, detailed measurements of the 21-cm power spectrum and its evolution could lead to measurements of the properties of early galaxies that are otherwise inaccessible. During 2013, we made predictions for the ionised structure during reionisation and the 21-cm power spectrum based on detailed models of galaxy formation. We combined the semi-analytic galform model implemented within the Millennium-II dark matter simulation with a semi-numerical scheme to describe the resulting ionisation structure. Using these models we showed that the details of supernovae (SNe) and radiative feedback affect the structure and distribution of ionised regions, and hence the slope and amplitude of the 21-cm power spectrum. These results indicate that forthcoming measurements of the 21-cm power spectrum, including those with the MWA, can be used to uncover details of early galaxy formation. (Kim, Wyithe)

During 2013 we continued our state-of-the-art program of cosmological hydrodynamic simulations to better understand the interplay between galaxies and the intergalactic medium (IGM) from redshift $z \sim 2$ to the epoch of reionisation at $z = 6$ and above. Deep and wide imaging campaigns with facilities such as SkyMapper will discover distant galaxies and quasars. At the same time, spectroscopic studies of bright, high redshift quasars with optical and near-IR facilities will probe the intergalactic gas which these early galaxies form from and subsequently interact with. Detailed models of this complex, non-linear interaction are vital for interpreting forthcoming data and for guiding future observational programs. We have made substantial progress towards this goal, combining a large grid of photoionisation modeling with hydro-dynamic modeling of galactic star formation and star formation driven outflows. Our theoretical program was used to interpret observations of the transverse proximity effect and metal lines in close proximity to foreground galaxies. (Tescari, Bolton, Schmidt, Singh, Wyithe)

CAASTRO University of Melbourne team members

(Left) Professor Rachel Webster and Dr Alan Duffy getting ready for the day's brain work at Uluru, NT.
Photo: Courtesy Damien Hill, Uluru Photography

(Right) Rachel Webster working hard with Dr Andre Offringa (ANU).
Credit: Kim Dorrell

In 2013 we also completed our cosmological hydrodynamic simulation program studying the role of feedback in regulating star formation in the highest redshift galaxies. This project focused on what can be learned about high redshift galaxy formation from the details of the star-formation rate function. Using a suite of hydrodynamic simulations and including different physical properties for the feedback, we modelled the star formation rate function for comparison with observations, concluding that high redshift galaxy formation is regulated by a combination of strong supernova feedback and AGN feedback. (Tescari, Bolton, Katsianis, Wyithe)

Additionally, during 2013 we extended our simulation studies to study the stellar mass function. This project, which forms the thesis of CAASTRO PhD student Katsianis, is focusing on what can be learned about high redshift galaxy formation from the details of the relation between stellar mass and star-formation rate. Using a suite of hydrodynamic simulations and including different physical properties for the feedback, we have modelled the stellar mass function for comparison with observations. Our results show that feedback is not a crucial consideration in the relation between stellar mass and star-formation rate, and that the disagreements between various observations arise in the implementation of dust corrections. (Tescari, Katsianis, Wyithe)

Also during 2013, we studied the kinematics of a large subset of spiral galaxies from the HIPASS (HI Parkes All-Sky Survey) catalogue. We have taken the spectral data using the WiFeS instrument on the Australian National University (ANU) 2.3m Telescope from May 2012 to June 2013. Using the data, we have calculated the velocity dispersions from the bulge of the spiral galaxies to find a third parameter in the Tully-Fisher relation (TFR). Since the circular velocity is calculated from the disk of a galaxy, the ratio of velocity dispersion to circular velocity could be an indicator of the morphology of a galaxy. Moreover, the slope of the TFR changes with the morphological type. Therefore, we investigated this ratio as a third parameter to reduce the scatter in the TFR. The primary use of the TFR is the determination of distance to spiral galaxies for parameters that are readily measurable, hence better correlations in the relation are needed to get better estimations of the distances to galaxies. We also argued that this method could help to improve our understanding of galaxy evolution and be used to study the TFR at higher redshifts without knowing the types of the galaxies (Mould, Webster, Ozbilgen).

2013 saw the development of a number of Real Time System (RTS) features required to achieve high fidelity across the wide MWA field of view. It also saw the creation or improvement of a number of auxiliary tools that interface the RTS with archived visibilities and meta-data, and that facilitate integration and/or deconvolution of RTS snapshot images. For example, imaging with a robust weighting scheme is now available in the RTS in CPU mode and is under development in GPU mode. Multi-component source calibration/processing has been implemented, and shapelet models of resolved sources can now be handled in the RTS. In addition, calibration on shapelet modelled sources is now also available. Tools have been developed to check the quality of the data (through the calibration solution) and to monitor the calibration stability during an observation session. These developments are critical for the analysis of MWA EoR data that will be a focus during 2014. (Mitchell, Webster, Pindor, Procopio, Riding)

Finally, we used semi-analytic Lyα forest simulations to assess the impact of He II reionisation on the recovered accuracy of the BAO scale. Inhomogeneous He II reionisation is driven by bright, rare quasars which can result in large-scale UV background and temperature fluctuations that could potentially affect the fractional precision to which the BAO scale can be recovered from the Lyα forest. Investigating a variety of He II reionisation models, we assessed their impact on the statistical measurements of the Lyα forest and find that He II reionisation can produce a fractional increase of ~50 percent in power at large-scales in the 3D Lyα flux power spectrum, reducing to ~5 percent at 0.03 Mpc^{-1}. However, despite the fractional increase in the large-scale power, we do not find any change in the predicted accuracy to which the BAO scale can be recovered. (Greig, Wyithe, Bolton)

Outreach and Professional Development Activities

The Melbourne node continued to make strong contributions in outreach, public, and professional education activities throughout 2013 – from public lectures, to school visits, to our terrific Year Ten work experience program, and by contributing stories and comments to the popular science media and general press.

Alan Duffy, for example, has been active in outreach, speaking to hundreds of students across the Pilbara Region of WA as part of the Federal Initiative Inspiring Australia and Pilbara Joblink's Science Career Carousel, which included visits to local Indigenous schools to speak about Aboriginal Astronomy. He and Katie Mack have continued their co-hosting of CAASTRO's Pint in the Sky video series, interviewing internationally renowned science communicators Dr Phil Plait (Bad Astronomer) and Henry Reich (MinutePhysics) in Canberra during National Science Week.

In March 2013 the University of Melbourne hosted a joint workshop between the ARC Centre of Excellence for Particle Physics at the Terascale (CoEPP) and CAASTRO. Aimed primarily at early career researchers and higher degree students from across Australia, the two day event attracted 63 participants. Initial presentations summarised the current status of studies into dark matter, neutrino physics and astrophysics, dark energy and modified gravity, leading into more detailed talks on topics such as inflation, dark matter detection, dark energy theories, and neutrino models. One clear outcome of the workshop was the reinforcement of the idea that better links between the two centres would be hugely beneficial for the missions of both. With a strong presence in both research areas, the Melbourne node is well placed to facilitate further collaborations.

A key highlight of the year, in July, was the staging of our first international science meeting: *Reionisation in the Red Centre: New windows on the high redshift universe*, at the iconic Northern Territory location of Uluru (Ayers Rock). More than 30 local attendees were joined by a further 40 colleagues from the US, UK, Europe, India and Korea, with an active social program including sunrise camel riding, bushwalks, and desert dining experiences contributing to a lively and stimulating five day event. Many of the international guests and speakers made follow up visits to the Melbourne node in the weeks following the conference, providing further opportunities for face-to-face collaboration and presentations to those unable to attend the main event.

2013 also saw the completion of the pilot stage of the *Telescopes in Schools Program* developed by members of the Melbourne node. All ten telescopes have now been installed in underprivileged schools across Melbourne and regional Victoria. There was a focus on Astrophotography this year with a competition in October. This CAASTRO-co-sponsored event was completed with an award ceremony at Scienceworks, with the winning entries exhibited in the Melbourne Planetarium foyer. CAASTRO PhD students and postdocs have also regularly attended schools to give talks and to help out on observing nights for the program.

Melbourne was also host to a day of early career researcher and student professional development immediately preceding the CAASTRO Annual Retreat. 16 participants attended a workshop on professional scientific writing: *Writing clear science – for grant and job applications*, organised by CAASTRO Education and Outreach Coordinator Dr Wiebke Ebeling.

As in previous years, the team at Melbourne was ably assisted throughout 2013 by executive officer Kim Dorrell, who very efficiently managed local node affairs while contributing to the organisation of national events like the CAASTRO-wide Annual Retreat at Torquay, Vic and the international Scientific Meeting held at Uluru, NT.

Judging by the feedback we received, this year's Year 10 Work Experience program was our most successful to date.

Academic Coordinator, CAASTRO PhD candidate Catherine de Burgh-Day, received the most ever personal 'thank you' emails and letters from students, teachers and parents expressing their enjoyment of the week long introduction to the work life of Australian astrophysicists.

Dr Ned Taylor's talk was voted one of the most popular on the Student Feedback Forms, while students benefitted from presentations and lab activities hosted by many local CAASTRO and Astrophysics staff and students.

This year we introduced an Observing Night into the program, held at the University of Melbourne, in cold but obliging weather. This was coordinated by CAASTRO's Catherine Trott and Jacinta den Besten of the Telescopes in Schools Project. Many parents took up the invitation to join their children in observing and learning about our universe.

Credit: Jacinta Den Besten

Professor Rachel Webster

CAASTRO Chief Investigator
Theme: Evolving

During 2013 Webster played a key role in the management of the international Epoch of Reionisation collaboration. She has led two MWA observing proposals, with a total over 700 hours observing time awarded in the first two semesters. In 2014 she will become spokesperson for the EoR collaboration. In addition, in collaboration with Catherine de Burgh-Day and Edward Taylor, significant progress has been made on the development of the new 3-D weak lensing algorithm, Direct Shear Mapping.

Professor Stuart Wyithe

CAASTRO Chief Investigator, University of Melbourne Node leader,
Evolving Universe Theme Leader
Themes: Evolving, Dark

In 2013 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 will initiate new programs to model the cross-correlation between HI and galaxies with application to the CAASTRO intensity mapping experiment, and will perform hydro-dynamic simulations of SAMI 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-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 haloes. She also intends to develop a project based on the SAMI survey to make DSM measurements in the local universe, and to use these observations to measure individual DM haloes as well as measure parameters in the standard cosmological model.

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 visibility 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.

Mr Brad Greig

CAASTRO PhD student
Theme: Dark

After submitting his thesis, *Ly-alpha as a cosmological probe of dark energy: assessing the impact of systematics* in August 2013 Greig took up a postdoctoral research position at Scuola Normale Superiore, Italy. His work, which focussed on calculating how intergalactic absorption effects the clustering of Ly-alpha emitting galaxies, was formally passed in early January 2014.

Dr Han-Seek Kim

CAASTRO Affiliate
Theme: Evolving

In 2013 Kim worked on studies of the cross-correlation between galaxies and the 21cm power spectrum of the Epoch of Reionisation. Additionally, he worked on the effect of reionisation on the HI mass function at local Universe. He also worked on extending his reionisation simulation to produce reionisation maps within much larger simulation volumes. In 2014, he plans to work on generating mock observations for MWA at EoR and HI intensity maps at intermediate redshifts using GiggleZ or MXXL large volume dark matter simulations.

Dr Akila Jeeson-Daniel

CAASTRO Postdoctoral Researcher (Jan-Sep); Affiliate (Sep-ongoing)
Theme: Evolving

Jeeson-Daniel completed her 1 year contract at CAASTRO in Sep 2013 and converted to affiliate membership. During 2013, she developed the pipeline for the batch mode simulations of Lyman Alpha Emitters at redshift 3 with special focus on resolving the circumgalactic and intergalactic gas around these galaxies which could play an important role in clustering of these objects. It is currently in the final phase of testing and the final suite of runs and the analysis of the data is planned for early 2014.

Mr Antonios Katsianis

CAASTRO PhD student
Theme: Evolving

Katsianis began his PhD during 2012 studying the properties of high redshift galaxies via numerical simulation where he is focussed 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 is also testing the consistency of observations from different surveys. In 2014 he will expand this work for lower redshifts and will investigate the evolution of the star formation rate-stellar mass relation.

Mr Jack Line

CAASTRO PhD student
Theme: Evolving

Line's PhD research focusses on interferometric instrumental effects. Specifically, he has been investigating the effects of time averaging on MWA data, and how the RTS can mitigate these effects. As the EoR signal is so weak compared to foregrounds, it is important that we understand these effects to make a detection.

Dr Katherine Mack

CAASTRO Affiliate
Themes: Evolving, Dark

Mack is working with CAASTRO members to improve models of the evolution of the reionisation-era universe and to explore new observational avenues in the area of dark matter particle physics. Using her theoretical expertise, Mack has formed new collaborations within CAASTRO aiming to connect observational and numerical projects to new theoretical developments.

Dr Daniel Mitchell

CAASTRO Research Fellow
Theme: Evolving

Throughout 2013, Mitchell led the final stages of the development of the RTS data reduction system for MWA archived visibilities. The RTS is now commissioned on several large supercomputers, as well as local development machines. The RTS commissioning team is in the final stages of preparation for it first major data processing run. In December 2013, Mitchell moved to take a position in the Computing Group at CSIRO Astronomy and Space Science.

Ms Sinem Ozbilgen

CAASTRO MSc student
Theme: Dark

Throughout 2013, Ozbilgen worked on obtaining WiFeS IFU cubes of ~100 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 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 Tully Fisher Relation.

Dr Bart Pindor

CAASTRO Affiliate
Theme: Evolving

In 2013 Pindor has been working on software tools and calibration strategies aimed at processing large amounts of MWA data though the MWA Real-Time System on GPU-based HPC facilities at iVEC and Swinburne. Significant milestones this year have included largely automated processing of several terabytes of EoR data, as well as the first successful generation of 2-dimensional power spectra from RTS images.

Dr Pietro Procopio

CAASTRO Postdoctoral Researcher
Theme: Evolving

Procopio is part of the RTS team processing data on the Fornax and gSTAR GPU clusters, which is currently investigating optimal ways to process the EoR test set. In particular, he is working on the RTS calibration of the EoR field in the context of the MWA EoR collaboration. During 2013 he developed software to extract RTS calibration solutions for data quality assurance summaries on the MWA EoR observing website, and is currently working on internal RTS routines to robustly estimate noise levels in MWA visibilities.

CAASTRO AT SWINBURNE UNIVERSITY OF TECHNOLOGY

Mr Tristan Reynolds

CAASTRO Masters student
Theme: Evolving

Reynold's thesis considers extensions to the EoR measurements being undertaken at the Melbourne node. Sensitivity of the FAST telescope to EoR HII regions will be calculated using semi-analytic modelling, following the work of Geil and Wyithe (2009), and will then be extended to consider signatures due to X-rays in the early EoR regime.

Ms Nastaran Rezaee

CAASTRO MPhil student
Theme: Evolving

Throughout 2013 Rezaee's work involved simulating and generating the visibilities for 32 antennas with 30.72 MHz of bandwidth centred at 154 MHz by MAPS (MIT Array Performance Simulation). In 2014 she will be simulating the full array and reducing the dataset using CASA (Common Astronomy Software Applications) to apply the Clean algorithm to synthesise the images, and to analyse the data for the characterisation of the noise.

Mrs Jennifer Riding

CAASTRO PhD student
Theme: Evolving

During the first half of 2013 we commissioned the MWA which became fully operational in July. 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. This method is outlined in the paper Riding et al 2013 (submitted).

Dr Edward (Ned) Taylor

CAASTRO Affiliate
Theme: Dark

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 2013 Tescari continued the simulation project started in 2012 to explore the interplay between galaxies and intergalactic gas at high redshift. The new simulations are currently used to study several scientific cases. Two papers have been submitted to MNRAS. The first showed that a combination of efficient supernova driven winds and early AGN feedback in low mass galaxies is needed to reproduce observed star formation rate functions of high redshift galaxies, while the second paper (the first author is CAASTRO PhD student Antonios Katsianis) investigated the evolution of the star formation rate – stellar mass relation and galaxy stellar mass function of the same sample of high-z galaxies.

In 2013 CAASTRO numbers at Swinburne continued to grow, with Fabian Jankowski starting his PhD on pulsars and fast radio bursts and Dr Ewan Barr and Dr Evan Keane commencing postdoctoral positions as part of the Dynamic Universe theme.

We said goodbye to Professor Warrick Couch who took up the position of the Director of the Australian Astronomical Observatory. In Warrick's place A/Prof Chris Blake became a Swinburne CI.

There were two major scientific highlights, the first being the announcement in *Science* that CAASTRO scientists were part of the discovery of a new population of fast radio bursts at cosmological distances. The second was that simulations were used to validate a clever new method to improve analysis of the WiggleZ observations that achieved an effective improvement in the signal to noise ratio of the "wiggles" equivalent to a doubling of the observation time.

Swinburne software engineer Andrew Jameson designed and implemented a CPU/GPU cluster that was deployed at the Molonglo radio observatory to be used instead of the originally planned FPGA correlator. This system has been used to successfully process observations of the Vela pulsar and is being used to debug the receiver system in order to be able to coherently add the different subsections of the array. Ewan Barr has been helping to optimise the supercomputer for fringe finding and we have been working with ANU's Frank Briggs and Manisha Caleb and Dr Chris Flynn on this project, along with Duncan Campbell Wilson and Dick Hunstead from the University of Sydney.

External visitors on this project included Dr Nie Jun from the Chinese QTT project for 6 months.

Staff at Swinburne also created a large number of animations of scientific phenomena for CAASTRO staff to publicise their work, available at http://www.astronomy.swin.edu.au/production/?topic=medialibrary

Professor Matthew Bailes

CAASTRO Chief Investigator
Theme: Dynamic

In 2013 Bailes was involved in the discovery of Fast Radio Bursts with the Parkes 64m telescope published in *Science* and began overseeing the upgrade of the Molonglo telescope to a digital system using a new CPU/GPU correlator instead of the planned FPGA system. By the end of 2013, 16 modules of the Molonglo antenna were routinely observing the Vela pulsar. Bailes was also part of the team which discovered a large number of new millisecond pulsars with the Parkes telescope and worked with Ewan Barr on a new accelerated pulsar search pipeline.

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 and galaxy velocities. He works with data sets including the WiggleZ Dark Energy Survey, 6dF Galaxy Survey and Galaxy and Mass Assembly Survey (GAMA). In 2013 he led papers using the large-scale topology of the WiggleZ galaxy distribution to perform new and accurate measurements of cosmic distances, and using multiple galaxy tracers in the GAMA survey to improve analyses of the growth of structure. His other main research interest is in combining large-scale structure and weak gravitational lensing surveys to test models of gravity.

Professor Jeremy Mould

Caastro Chief Investigator
Theme: Dark

During 2013 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. Mould also measured supernova host redshifts during an OzDES run over Christmas.

CAASTRO Swinburne University of Technology Team members

Dr Ewan Barr

CAASTRO Postdoctoral Researcher
Theme: Dynamic

Barr commenced with Swinburne in 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 GPUs to enable real-time searches for binary pulsars. Barr's work has also seen him involved in the recomissioning 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. Barr joined CAASTRO from the Max Planck Institut for Radioastronomie, where his PhD focused on searching for and timing radio pulsars with the 100-m Effelsberg telescope.

Professor Karl Glazebrook

CAASTRO Affiliate

Glazebrook's main activity in CAASTRO has been the initiation and early development of the OzDES project, which is 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 Postdoctoral Researchers.

In 2013 the OzDES team secured 100 nights on the 3.9m Anglo-Australian Telescope for their work and signed an MoU with DES. At the end of 2013 the first OzDES runs were highly successful in securing spectra of numerous high-redshift supernovae and their host galaxies. At the end of 2013 Glazebrook handed over formal leadership of OzDES to fellow CAASTRO member Dr Chris Lidman but remains actively engaged in the science.

Mr Andrew Jameson

Software Engineer
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.

Mr Fabian Jankowski

CAASTRO PhD Student
Theme: Dynamic

Jankowski commenced his PhD at Swinburne in September 2013 under the supervision of Prof. Matthew Bailes and Dr. Willem van Straten. His interest is in pulsar science and radio transients. He is mainly involved in re-commissioning the Molonglo radio telescope. As a first step he investigated the population of pulsars and radio bursts that would be observable with Molonglo. Since then he has implemented an automatic observing mode, taken data nearly every night, worked on pulsar timing, built an analysis pipeline for the incoherent mode and helped in debugging the instrument. He is also involved in, and leads observation proposals for the Parkes telescope.

Mr Andrew Johnson

CAASTRO PhD Student
Theme: Dark

Johnson is involved in measuring the growth rate of structure (the rate at which density perturbations grow) on very large cosmological distance scales. This is being done using the 6-degree Field Galaxy Survey velocity (6dFGSv) sample, the current largest peculiar velocity dataset in existence. The measurements allow constraints to be placed on modifications to Einstein's gravity, as invoked to explain the current accelerating expansion of the universe.

Dr Eyal Kazin

CAASTRO Postdoctoral Researcher
Theme: Dark

Kazin's research involves analysing the distribution of galaxies on cosmic scales of hundreds of millions of light-years to better understand the constituents and evolution of the universe. In 2013 Kazin has completed and published two investigations. In the first he used galaxies from the Australian WiggleZ Dark Energy Survey, and improved inferred distance measurements by applying a technique called "reconstruction of the density field". Using the same galaxy sample as has been previously analysed and reported, this technique ultimately improved distance constraints to a unique redshift of $z=0.73$ from 6% accuracy to 3.4%, which is effectively equivalent to that expected with a survey 2.5 times in size. Other main contributors to this project were Dr. Jun Koda and Dr. Chris Blake. In a second analysis, Kazin used a galaxy sample with the largest volume, at the time, from the renowned Sloan Digital Sky Survey, and applied a new technique which he developed called "clustering wedges" to measure the cosmic expansion rate at $z=0.57$ at an accuracy of 6.5%, and a distance measurement at 3% uncertainty. With the ever growing sky surveys that will yield more accurate results, this publication set the standard for future analyses. In both publications the results showed consistency with a ΛCDM universe, i.e, an accelerating one containing dark matter.

Dr Evan Keane

CAASTRO Postdoctoral Researcher
Theme: Dynamic

In 2013 Keane calculated discovery rates of Fast Radio Bursts for current and next generation telescopes. He was involved in the discovery of a magnetar 0.1 parsecs from the supermassive black hole in the Galactic Centre. Additionally he was part of a team that discovered 24 new pulsars using the Einstein@ Home citizen science project, calibrated a model for ionospheric Faraday rotation corrections using observations with the LOFAR telescope and studied the phenomena of "drifting sub-pulses" across a wide frequency range for the first time.

Dr Jun Koda

CAASTRO Postdoctoral Researcher
Theme: Dark

In 2013, Koda completed the work of forecasting the cosmological constraints expected for the future peculiar velocity surveys, TAIPAN and WALLABY. These surveys can provide unique constraints on the growth rate of large-scale structure of the Universe, which can discriminate modified theories of dark energy or modified gravity from the current standard cosmological model. He also developed a new cosmological simulation code for generating many galaxy catalogues. The set of mock catalogues generated with the code played an important role to evaluate the uncertainties in the new revised WiggleZ cosmic distance measurement lead by Eyal Kazin.

Dr David Lagattuta

CAASTRO Postdoctoral Researcher
Theme: Dark

In 2013 Lagattuta published the results of the WISE Tully-Fisher project: the largest (and first truly all-sky) mid-infrared sample of Tully-Fisher (TF) galaxies ever assembled. Through this work he characterised new TF systematics - an important step in measuring peculiar velocities - and provided insights into galaxy dynamics at the boundary between stellar- and gas-dominated emission.

In addition, Lagattuta has also been actively involved with the OzDES survey, taking part in both planning and observing. Through OzDES he has also joined the larger DES collaboration as part of the Strong Lensing Working Group: a small team dedicated to identifying and studying newly-discovered strong gravitational lenses in the DES footprint. With these newly-discovered systems, he intends to expand upon the efforts of SHARP, a project using gravitational lenses to search for dwarf satellite galaxies beyond the Local Universe.

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. Petroff is using data from the most advanced pulsar survey ever conducted at the Parkes radio telescope, the High Time Resolution Universe Survey, to search for new pulsars through single pulse emission. Petroff focuses on expanding the population of known pulsars to study the distribution and density of the interstellar medium of the Galaxy. Petroff has also begun searching the survey for fast radio bursts, a new and mysterious class of fast transient.

Dr Emma Ryan-Weber

CAASTRO Associate Investigator

Ryan-Weber's research in 2013 focused on observational constraints on reionisation, which fits within the evolving theme. Specifically, she has worked on the cosmological mass density of triply-ionised carbon at redshifts greater than 5; the connection between this carbon, galaxies and their large-scale environment; and the escape fraction of ionising photons from high redshift galaxies.

Australian National University

CAASTRO AT THE AUSTRALIAN NATIONAL UNIVERSITY (ANU)

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 dataset are being built from SNLS, SDSS, and CSP supernova surveys for this work. Additional data sets may come from the DES and SkyMapper surveys. With a large dataset and controlled analysis methods for photometry and SED fittings, this work has the potential to improve systematic uncertainties originating from different host galaxy properties (e,g., dust extinction) in supernova light curves. Understanding the force responsible for cosmic acceleration is an important implication of this work.

Uddin has been involved in the OzDES collaboration in which the AAOmega spectrograph on AAT is used to follow-up supernovae candidates discovered from DES. First year OzDES observations are finished and an article has appeared in AAObserver. Several supernova discovery confirmation telegrams have also been published. Papers will be submitted summarising first year results.

Uddin has also joined the SNLS collaboration after a meeting in Paris in October 2013.

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 design of the pulsar timing instrumentation for the Square Kilometre Array. van Straten is actively involved in the High Time Resolution Universe survey based at the Parkes Observatory in New South Wales. For this project, he supervises PhD student Emily Petroff's search for fast radio bursts and rotating radio transients.

Ms Sue Lester

Node Administrator

Lester has been the CAASTRO Administrator at Swinburne for the past two years. She has a Graduate Certificate in Business – Executive Administration and a Diploma of Sustainability. Lester works on a part-time basis and enjoys assisting the CAASTRO researchers and students and communicating with other node administrators throughout the year. Lester assisted once again at the annual retreat held in Torquay, Victoria.

Research at the ANU node of CAASTRO spans the breadth of the Centre's activities, with extensive links into the other nodes.

Within the Evolving theme, student Jonghwan Rhee and Prof. Frank Briggs used the GMRT telescope in India to measure the content of neutral HI in normal field galaxies spanning redshifts from $0.1<z<0.4$. This research is allowing us to study the evolution of typical galaxies back 4 billion years in time, and is a precursor for what should be possible with SKA and its pathfinders.

Also within the Evolving theme, PhD student Ben McKinley, Dr. André Offringa, and Prof. Frank Briggs have been working with the Murchison Widefield Array (MWA) to both commission and calibrate the instrument, to characterise and mitigate radio frequency interference, and to help design and implement software that enables calibration and imaging. These pursuits help MWA to achieve its design specifications for the common good, but they have also enabled the ANU group to undertake studies in detection of the Epoch of Reionisation as limited by radio interference, a detailed study of the giant radio lobes of nearby galaxies, and a study of the radio emission at low frequencies of galaxies that reside in clusters.

A key contribution to future work within the evolving theme will include observations of the southern sky by the SkyMapper telescope. In 2013, final commissioning work was finished by the SkyMapper team including Dr. Chris Wolf and Dr. Patrick Tisserand, with the telescope now taking data on a nightly basis in a fully automated fashion.

Within the Dynamic Theme, work has cut across both the optical and radio domains. The optical team includes Dr. Fang Yuan, Dr. Michael Childress, Dr. Richard Scalzo, Dr. Chris Wolf, and Prof. Brian Schmidt. Using the SkyMapper telescope, Dr. Fang Yuan and Dr. Richard Scalzo successfully deployed a transient pipeline that discovered its first supernova in October, with a total of 10 confirmed supernovae discovered by year's end. 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 Supernoae (SN Ia) from the evolution of their spectra. Scalzo on the other hand, has successfully modeled the masses of SN Ia from similar observations, making the discovery that their masses seems to vary as a function of their intrinsic luminosity.

At radio wavelengths within the Dynamic theme, student Manisha Caleb has been working with the Swinburne node to detect the mysterious Fast Radio Bursts. Using the Molonglo radio telescope, Caleb is helping reengineer this facility to operate in wide-field survey mode with expanded bandwidth to transform it into a powerful frontline burst finding machine. Dr. Yuan is coordinating efforts to then follow-up any such bursts with optical imaging, to help identify these objects. If found to be at extragalactic distances, they represent some form of unknown physics to date, and offer the prospect of characterising the amount of ionised gas in the Universe as a function of look-back time.

Efforts in the Dark Theme are concentrated around optical projects that probe Dark Energy. As part of the WiggleZ team, Prof. Matthew Colless was part of work that probed the growth of structure, a key diagnostic of the detailed behaviour of Dark Energy. The ANU optical group joined the OzDES consortium, which seeks to use the Anglo-Australian Telescope to gain redshifts for many thousands of SN Ia observed as part of the Dark Energy Survey on the CTIO Blanco Telescope. As part of our group's activities, we designed and implemented the project's web page (which is used to manage the program, as well as provide information), and have participated in observing runs at Siding Spring Observatory. We expect extensive datasets to become amassed by the end of 2014, which then can be combined with the first SkyMapper SN Ia datasets for a precision measurement of cosmic acceleration.

Professor Brian Schmidt

CAASTRO Chief Investigator, Dark Universe Theme Leader (until December); Gender & Diversity Committee Chair (starting in December)
Themes: Evolving, Dynamic, Dark

Schmidt continued to lead work on SkyMapper, including finalising commissioning activities and software development. Regular operations have now commenced, although improvements to the telescope performance will continue through 2014. The SkyMapper Supernova Survey found its first set

CAASTRO ANU Team members

of objects in October 2013, and is regularly making discoveries as part of its on-going activities. Schmidt continues to make many public appearances both in Australia and internationally, which in 2013 included 19 separate events overseas. In January Schmidt was given Australia's highest civilian honour, a Companion of the Order of Australia.

Professor Frank Briggs

CAASTRO Chief Investigator
Themes: Evolving, Dynamic

Briggs' research interests have focused on the use of the radio 21cm 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 spent much of 2013 participating in the testing and commissioning of this next phase of the MWA project. He is also engaged in an ongoing collaboration with Indian astronomers at the National Centre for Radio Astrophysics in Pune to use the Giant Metrewave Radio Telescope (GMRT) to measure the evolution of the gas content of galaxies over the last 7 billion years and the relation of the gas to star forming properties of galaxy populations. In 2014, he will continue his research on radio techniques, with emphasis on the characterisation and suppression of the effects of radio frequency interference.

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 TAIPAN UKST surveys. As a member of all four survey teams, Colless plans to study the co-evolution of gas and stars out to a redshift $z \sim 0.25$ using the ASKAP radio surveys to measure the neutral hydrogen gas component of galaxies and the UKST optical spectroscopy to measure the stellar component.

Ms Manisha Caleb

CAASTRO PhD Student
Theme: Dynamic

Caleb began her PhD in July 2013 under the supervison of Frank Briggs at ANU and Matthew Bailes at Swinburne. Fast Radio Bursts are one-off events, similar to Rotating Radio Transients but of unknown origin and thought to be at cosmological distances. For her PhD, she is analysing the ability to document polarisation properties of single pulses from Rotating Radio Transients and in the process Fast Radio Bursts. She is also helping to commission the Molonglo Radio Telescope to transform it into a burst finding machine under the supervision of Matthew Bailes.

Dr Michael Childress

CAASTRO Postdoctoral Researcher
Theme: Dark

Childress' research focuses on observational constraints on the progenitors of Type Ia supernovae with a particular emphasis on optical spectroscopy. In 2013 Childress had five papers accepted for publication: two papers from his thesis work on host galaxies of Type Ia supernovae and their connection to cosmology, a paper on the very nearby supernova SN 2012fr plus a followup paper on high-velocity features in Type Ia supernova spectra, and a paper on the new data reduction pipeline for the WiFeS instrument.

Ms Sarah Leslie

CAASTRO Pre-PhD Student
Theme: Evolving

Joining in November 2013, Leslie has spent time at The University of Sydney analysing the radio continuum emission of galaxies in the SAMI galaxy survey under the supervision of Elaine Sadler and Julia Bryant. Both the radio continuum and Hα emission are used to estimate star formation rates in galaxies. Leslie has been studying spatially resolved radio and optical emission from star forming galaxies to provide insights into the physics behind these relations for galaxies with a wide range of stellar masses. Her supervisor at ANU is Lisa Kewley.

Mr Benjamin McKinley

CAASTRO PhD Student
Theme: Evolving

McKinley found that working on low-frequency radio astronomy with the Murchison Widefield Array (MWA) inspired him to change careers (from engineering) and this has been the main focus of his PhD, which he will complete in 2014. McKinley is particularly interested in survey science with the MWA. He is part of the team working on calibration, imaging and analysis of data from the Galactic and Extragalactic All-sky MWA (GLEAM) survey. He will use the GLEAM data to study extragalactic radio-source populations, and broaden his knowledge by working with data at higher frequencies. McKinley is also interested in using the MWA as a passive radar device to track space debris.

Dr Andre Offringa

CAASTRO Postdoctoral Researcher
Themes: Evolving, Dynamic

Offringa joined CAASTRO in 2012 as a 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).

Ms Sharon Rapoport

CAASTRO PhD Student
Theme: Dynamic

Rapoport joined CAASTRO's ANU team as a PhD student in 2011. She is working 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. In the next year Rapoport will create a grid of synthetic light curves and spectra to explore the parameters space of different models by varying for e.g. explosion energy, asphericity and progenitor mass, to allow easier identification of newly observed GRB-SN.

Mr Jonghwan Rhee

CAASTRO PhD Student
Theme: Evolving

Rhee joined the CAASTRO ANU team as a PhD student in 2011. He is working on atomic neutral hydrogen (HI) gas evolution in field galaxies over cosmic time ($0.1 < z < 0.4$), using 21-cm HI emission line stacking techniques. In 2013 he published the analysis of data taken from the WSRT, which presented the most reliable HI density measurement beyond the local universe using an HI spectral stacking technique, and showed no evolution in the neutral hydrogen gas over the last 4 Gyr. He also finished data reduction of a large volume of the GMRT data for two galaxy fields. In the next year, he plans to complete the analysis of the two fields and submit the results to a journal.

Dr Ashley Ruiter

CAASTRO Associate Investigator
Theme: Dynamic

Ruiter works in binary star evolution modelling. Her research focuses on determining the evolutionary channels that lead to the formation of transient sources, in particular Type Ia supernovae. Ruiter became a member of CAASTRO in October 2013 and will join ANU in April 2014.

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. Together with colleague Dr. Fang Yuan, Scalzo has led the development and operation of SkyMapper's Supernova Search, which began science verification operations in September 2013 and found its first supernova (of Type Ia) in October 2013. He has also developed a method to reconstruct the mass ejected in a Type Ia supernova, applying it to a sample of nearby supernovae to place strong constraints on allowed explosion mechanisms. In 2014 Scalzo expects to discover and follow up many more supernovae in the local universe with SkyMapper, to apply the mass

reconstruction method to a much larger statistical sample of nearby supernovae, and to extend this method to reconstruct ejected masses for other types of supernovae.

Dr Ivo Seitenzahl

CAASTRO Associate Investigator
Theme: Dynamic

Seitenzahl became a CAASTRO Associate Investigator in October 2013 and will join 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. Seitenzahl's research also includes work on the formation and propagation of detonations powered by nuclear fusion, the Galactic chemical evolution of manganese, and the atomic and nuclear physics of late time supernova light curves.

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. When not working on adaptive optics instrumentation, Rob is involved in a number of CAASTRO projects. As an expert in fibre optic spectroscopy, Rob chairs the working group developing the analysis software for the SAMI galaxy survey, which will have its first major survey results later this year. As a founding team member for the OzDES supernova survey, Sharp is leading the radio galaxy component of this survey and is local coordinator for the "reverberation mapping" component, which will measure the masses of giant black holes in distant quasars.

Dr Christian Wolf

CAASTRO Associate Investigator
Theme: Evolving, Dark

Wolf started work as the SkyMapper Survey Scientist in April 2013 and has worked on the commissioning of the SkyMapper 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 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 has published a paper constraining the nature of peculiar sub-luminous transients through statistical studies of their locations. She is carrying out studies of a nearby core-collapse supernova that aim to link the observed explosion characteristics and properties of the massive star progenitor. She is also responsible for coordinating gamma-ray burst followup with SkyMapper and the ANU 2.3m. In 2013, she became a member of the OzDES team and led the development of the OzDES database and web applications hosted at ANU. In addition, she is helping to extend the "CAASTRO in the classroom" outreach program to Chinese high schools.

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 Dark Theme Leader, Professor Brian Schmidt as his assistant.

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

CAASTRO AT THE UNIVERSITY OF QUEENSLAND

During 2013, the University of Queensland joined CAASTRO as a seventh node. UQ brings some key theoretical expertise into the Dark Theme, as well as contributing observing and simulation experience into the Evolving and Dynamic themes.

UQ researchers have already been participating in many CAASTRO projects over the last few years. One of the major highlights of 2013 has been the work led by Signe Riemer-Sørensen, using large-scale structure data from the WiggleZ survey to constrain the mass of the neutrino, and the number of relativistic species in the early universe — in other words, doing particle physics using astronomical observations. In a series of papers we showed that adding galaxy power spectra from WiggleZ to the Planck data and BAO improved the upper limit to 0.18 eV for the sum of the mass of the three neutrino species (contrary to the Planck team's claim that adding power spectra would not significantly improve the constraints). Amongst the strongest limits yet published, this upper limit is now pushing down into the very interesting particle physics regime, because particle physics experiments show that the lower limit is either 0.05 eV or 0.10 eV for the normal or inverted hierarchies respectively. Tightening the limit further will therefore have very interesting implications for whether there are two heavy or two light neutrinos. Or alternatively, since this result assumes that dark energy is a cosmological constant, any tension could point towards interesting dark energy physics or problems in our structure formation models. In addition to the mass, we also published constraints on the number of neutrino species, and in combination with Planck data find that the slight preference for more than three neutrinos remains (at the two-sigma level), at $\sim 3.58 \pm 0.16$. To understand the implications of this for dark matter particles check out Signe's PASA review paper, "What is half a neutrino?".

Meanwhile, Tamara Davis helped initiate and set up the OzDES collaboration, which over the next five years will take spectra of thousands of supernova host galaxies, and measure time-lapse line profiles of hundreds of active galaxies to measure their black hole masses, amongst many other things. PhD student Anthea King submitted a paper investigating the usefulness of active galactic nuclei (AGN) as possible high-redshift standard candles, and initiated collaborations with the OzDES team to use reverberation mapping to measure the black hole mass and calibrate the luminosity of AGN discovered by the Dark Energy Survey (DES).

Davis has also been co-supervising CAASTRO student Morag Scrimgeour, who submitted her PhD this year. Her results included measurements of the homogeneity of the universe using the WiggleZ dark energy survey data, a measurement of the bulk flow of the local universe with the 6dFGSv data, and a prediction of the constraints expected with SkyMapper supernovae (with papers on the last two soon to be submitted).

Still on the Dark Theme, David Parkinson published a review article on Bayesian Model Selection in cosmology, summarising much of the research in this area including his own. With the complexity of modern data sets, and their interdependencies, robust statistical techniques are essential, and answering the question of "What is dark energy?" requires one to differentiate between finding the best parameters within a model and determining which is the best model, the latter of which is the question we really want to ask.

A new postdoctoral fellow to arrive to UQ in 2013, Jason Dossett, contributes his theoretical and computational expertise testing non-standard gravity models. He has continued to develop his publicly available analysis code, "Integrated Software in Testing General Relativity" (ISiTGR, pronounced "Is it GR?"), and applied it to testing non-standard gravity models. Dossett also updated the module written by Parkinson to use the WiggleZ dark energy survey data with the CosmoMC package — the Monte-Carlo Markov Chain sampler that most cosmologists around the world use to compare data to models - and with those updates, the data now also come as standard as part of the package.

We anticipate 2014 ramping up with a new CAASTRO postdoctoral fellow arriving at UQ to work on dark energy theory linked with CAASTRO observational projects, and with Michael Drinkwater & Holger Baumgardt joining the Evolving and Dynamic themes, respectively.

CAASTRO University of Queensland Team members

Assoc. Prof. Tamara Davis

Chief Investigator, CAASTRO Executive
Theme: Dark

Davis specialises in interpreting cosmological observations in terms of their implications for fundamental physics. In particular she focuses on determining the nature of dark energy and dark matter, using supernovae, large scale structure, and galaxy velocities. She is a leader of the OzDES project, which began in 2013 being awarded 100 nights over 5 years on the AAT to take spectra of sources discovered by the Dark Energy Survey (DES).

Dr Holger Baumgardt

CAASTRO Affiliate
Theme: Dynamic

Baumgardt's focus is on the role that direct collisions between white dwarfs have for the overall Supernova Type Ia rate in galaxies. In 2013, he worked on calculating collision rates between single white dwarfs in various stellar environments. He also started simulations that investigate the role of stellar binaries for these collisions.

Dr. Jason Dossett

CAASTRO Affiliate
Theme: Dark

Dossett has been working on cosmological tests of gravity in order to determine whether cosmic acceleration is due to a dark energy permeating the Universe or rather the need for a modification of our gravity theory on cosmological scales. His work focuses on developing and implementing tests in order to distinguish between these two scenarios. Most recently he and collaborators have used data from the Planck surveyor and the WiggleZ Dark Energy Survey to place constraints on f(R) modified gravity models. He is also the primary developer of the software package ISiTGR and has contributed code to some of the recent versions of CosmoMC.

Prof Michael Drinkwater:

Associate Investigator
Theme: Evolving

Drinkwater's research focus is on the origin and evolution of dwarf galaxies. He is using high-resolution observations and simulations to test models of the formation of the smallest galaxies, ultra-compact dwarf galaxies, which he discovered. He is also using the new Sydney Australian Astronomical Observatory Multi-object Integral Field Spectrograph (SAMI) to determine the importance of hydrodynamic processes in the evolution of galaxies in rich cluster environments.

Dr David Parkinson

CAASTRO Affiliate
Theme: Dark

Parkinson has been leading research into testing theories of modified gravity, as an alternative explanation for the accelerated expansion of the universe. His work has focussed on using measurements of the large-scale structure of the universe to test these models. He has developed theoretical predictions for growth of structure under Galileon models of gravity, using the multipole power spectrum measured by WiggleZ to constrain it.

Dr Signe Riemer-Sørensen

CAASTRO Affiliate
Theme: Dark

Riemer-Sørensen's focus has been on measuring the neutrino mass using the WiggleZ dark energy survey. After the publication of the Planck data last March, she led a combined analysis with WiggleZ data, which resulted in the strongest neutrino mass constraint to date from cosmology, as well as providing interesting information on the neutrino hierarchy. She also performed preliminary work for a project that could improve the measurements of primordial deuterium abundance by a factor of two.

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 expertise in the successful execution of large survey 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.

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 are all helping CAASTRO to create a world-leading research program. Bringing together this expertise in radio astronomy, optical astronomy, theoretical astrophysics and computation will enable CAASTRO to reach its vision of being an international leader in wide-field astronomy.

Associate Investigators

Dr Chris Lidman (AAO)

Dr Lidman's role is in the Dark Universe Theme, where he is contributing to the follow-up of Type Ia supernovae discovered by SkyMapper and the Dark Energy Survey. His expertise is in observational cosmology, Type Ia supernovae, galaxy clusters, primordial galaxies, and exotic transient phenomena. Lidman is an expert in adaptive optics, near-IR imaging and optical spectroscopy.

Dr Jamie Bolton, University of Nottingham

Dr Bolton is a Royal Society University Research Fellow and lecturer at the University of Nottingham, a position he has held since October 2012. In 2013 he continued to work with PhD student Brad Greig on developing simulations to calculate the effect of temperature fluctuations on the absorption statistics towards quasars.

Dr Stuart Sim, University of Belfast

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 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.

Partner Investigators

Australian Astronomical Observatory

Professor Warrick Couch

As Director of the Australian Astronomical Observatory, Professor Couch has a significant role in supporting the operations and management of CAASTRO because the AAO is providing some of the Centre's key facilities, through the wide-field optical spectroscopic capabilities of the Anglo-Australian Telescope (AAT). Of particular importance are the SAMI multi-integral field unit and AAOmega multi-fibre spectrograph facilities on the AAT, each of which play a key role in CAASTRO's three theme areas. Furthermore, Couch has a major leadership role in the SAMI Galaxy Survey, being a member of its Executive, and directing and resourcing research being undertaken in the "galaxy morphological transformation" area. In his position as AAO Director, he is also able to facilitate new scientific opportunities for CAASTRO through the AAO's involvement in projects such as the Dark Energy Spectroscopic Instrument (DESI) and 4MOST on the European Southern Observatory's 4-metre VISTA telescope.

Associate Professor Andrew Hopkins

Associate Professor Hopkins is coordinating the contributions of the Australian Astronomical Observatory to CAASTRO, together with AAO Director Professor Warrick Couch.

Hopkins manages and coordinates CAASTRO-supported student and postdoctoral researchers who observe with and utilise data from the Anglo-Australian Telescope. He facilitates AAO support astronomer interactions with CAASTRO personnel, coordinating pipeline data processing for observations with AAO facilities, and managing access to computing resources. Hopkins is responsible for identifying programs using AAO facilities that complement and add value to CAASTRO projects. By leveraging the existing effort on such projects, new scientific goals from CAASTRO projects will be enabled, increasing the return from the existing investment. Hopkins' primary research activities within CAASTRO fall under the Evolving Universe theme, although there are several overlapping aspects of his work with activities that CAASTRO will pursue under the Dark Universe theme. Within CAASTRO, Hopkins is primarily pursuing research on the EMU and the proposed TAIPAN projects.

Commonwealth Scientific and Industrial Research Organisation

Dr Brian Boyle

Dr Boyle is Project Director for the Australia and New Zealand SKA project. His primary research interests are in the fields of quasars, active galaxies and cosmology, and he is currently involved in the Australia Telescope Large Area Survey (ATLAS). The CSIRO is a world leader in science and engineering associated with radio astronomy, and is leading Australian efforts on the Square Kilometre Array. The CSIRO offers outstanding computational services, several of the world's most powerful radio telescopes, and a world-class engineering team.

Dr Simon Johnston

Dr Johnston is Head of Astrophysics for CSIRO Astronomy and Space Science. His interests are pulsars, radio transients and Extreme Scattering Events and he is thus closely aligned with the Dynamic theme. He is a key member of the VAST survey project proposed for ASKAP and is a member of the Pulsar Science Working Group for the SKA.

Professor Ray Norris

Professor Norris is Chief Research Scientist within CSIRO Astronomy & 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.

California Institute of Technology, USA

Professor Shri Kulkarni

Professor Kulkarni's focus within CAASTRO is in the Dynamic Universe theme. He has long-standing collaborative links with Professors Matthew Bailes and Brian Schmidt, as exemplified by a history of ARC grants in the areas of software correlation and instrumentation development applicable to the Square Kilometre Array, and gamma-ray bursts. Kulkarni is one of the originators of the Palomar Transient Factory (PTF), a northern-hemisphere complement to the Skymapper project. Using these facilities in concert, the CAASTRO team can monitor the entire sky for optical transients, and can share algorithmic and software development. Finally Swinburne and Caltech have already signed a Memorandum of Understanding of scientific collaboration that spans the early years of CAASTRO and provides access to the Keck telescopes for Swinburne astronomers. This MoU has triggered a number of new collaborative projects involving scientists from these two institutions. Professor Kulkarni has taken an interest in the origin of the Fast Radio Bursts, ruling out some scenarios for their origin and trying to ascertain whether they can be at cosmological distances.

University of Arizona, USA

Professor Xiaohui Fan

Professor Fan's primary involvement in CAASTRO science is within the Evolving Universe theme. In particular Fan will be active in the use of quasars to probe the evolution of the high-redshift intergalactic medium. 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. Fan will also play a lead role in the multi-wavelength followup of the high redshift quasars and their environments through the considerable resources available through the Steward Observatory which he is able to direct towards CAASTRO science.

Durham University, UK

Professor Carlos Frenk

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 FLASH, 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

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 of this exciting science starts with the search for fast transients. Kramer is contributing his expertise to this area by developing hardware and software solutions in collaboration with the CAASTRO partners.

Max-Planck Institute for Astrophysics, Germany

Professor Guinevere Kauffman

Professor Kauffmann's main research activities within CAASTRO are under the theme of the Evolving Universe. She brings to CAASTRO expertise on the analysis and interpretation of the physical properties of galaxies, with particular emphasis on their gaseous components.

She is currently leading two programs to characterise atomic and molecular gas in a sample of approximately 1000 nearby galaxies. As a precursor to surveys such as WALLABY that will be supported by CAASTRO, the knowledge gained in executing Kauffmann's programs is extremely valuable for the CAASTRO team.

CAASTRO COLLABORATIONS

CAASTRO staff have been involved in a number of collaborations with institutions both in Australia and internationally during the course of 2013, including the following:

Laboratoire de Physique Nucléaire et de Hautes Energies (LPNHE), France

Dr Reynald Pain

Dr Pain is contributing to CAASTRO's Dark Universe theme within CAASTRO. Pain is the Director of LPNHE, a large physics research grouping that works in a broad range of high-energy and particle physics experiments. As French lead investigator of the Supernova Legacy Survey (SNLS) project, Pain is one of the leaders of using type Ia supernovae to measure the acceleration of the universe. As part of CAASTRO, Pain and his team at LPNHE will actively participate in the SkyMapper supernova survey, taking leading roles in the calibration and precision photometric analysis of the supernova data.

University of Toronto, Canada

Professor Ue-Li Pen

Professor Pen brings to CAASTRO a wealth of experience in tackling fundamental problems in cosmology associated with many of the Centre's science themes. He has considerable experience in studies of the Epoch of Reionisation and of extragalactic hydrogen, and has worked in this area with fellow CAASTRO investigators. Within CAASTRO, Pen's research activities are primarily under the theme of the Evolving Universe. His specific focus is to quantify the errors in the power spectra of neutral hydrogen in galaxies, as measured by ASKAP surveys such as WALLABY & DINGO.

Raman Research Institute, India

Professor Ravi Subrahmanyan

Professor Subrahmanyan's focus within CAASTRO is the Evolving Universe theme. His background is in developing methods and instrumentation for all-sky measurements of the radio background – in particular detecting reionisation signatures in the cosmic radio background. Subrahmanyan and his colleagues at the Raman Research Institute are contributing primarily to the Murchison Widefield Array's efforts to detect the Epoch of Reionisation.

University of Oxford, UK

Professor Roger Davies

Professor Roger Davies is Head of Astrophysics at Oxford University. Within CAASTRO, Davies's contribution is primarily in the Evolving Universe theme. 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.

National Computational Infrastructure

Professor Lindsay Botten

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 2013, some 8 million CPU hours were utilised.

eROSITA

Institutions: Max-Planck-Institut für Extraterrestrische Physik, CAASTRO

The extended ROentgen Survey with an Imaging Telescope Array (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. In 2013, the German eROSITA consortium (eROSITA_DE) and CAASTRO signed a memorandum of understanding that enables collaboration on projects requiring combined data from eROSITA and from Australian wide-field facilities such as ASKAP, MWA, SKAMP, Parkes, ATCA, SkyMapper, AAT and TAIPAN. The agreement is overseeing science projects that require the use of both eROSITA_DE and CAASTRO data, involve at least one member from each of eROSITA_DE and CAASTRO, do not conflict with existing eROSITA_DE or CAASTRO projects, allow participation by undergraduate and postgraduate students, and adhere to the existing policies for the individual facilities involved (e.g. proprietary periods, data access, survey teams, observing time, publications). This arrangement will provide exciting new opportunities for multi-wavelength astronomy projects across the southern sky.

SkyMapper

Institutions: Australian National University, CAASTRO, Monash University, AAO

SkyMapper is a 1.35-metre telescope with a 5.7 deg^2 imager, located near Coonabarabran NSW, which is owned and operated by the Research School of Astronomy and Astrophysics at ANU. CAASTRO has secured $1.16M in ARC LIEF funding to secure membership of the SkyMapper consortium for all Australian astronomers. 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 allows the development of robust and efficient software pipelines, analysis tools and data access facilities. This collaboration is providing CAASTRO researchers and the wider Australian astronomy community not only with science-quality SkyMapper data but also with a consistent photometric system over the whole sky by combining SkyMapper data with that from PanSTARRS-1.

SkyMapper Supernova Search

Institutions: HEP-Paris VI, Australian National University, OZ-DES Collaboration, PESSTO Collaboration

Among the core goals of SkyMapper is a large 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 Ia 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 in June 2012. 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 OzDES 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.

ASKAP Early Science

Institutions: CSIRO, The University of Sydney, University of Western Australia, Curtin University, University of Minnesota, Monash University and others

The Australian Square Kilometre Array Pathfinder (ASKAP) will soon have 12 operating antennas, all equipped with phased-array feeds. While this is only a stepping stone toward the 36 antennas anticipated for the full ASKAP, an ASKAP-12 system will be a powerful survey instrument in its own right, with survey speed comparable to that of the VLA. CSIRO have accordingly announced an ASKAP Early Science program using ASKAP-12, to commence in 2014/2015. The focuses for early science are continuum polarisation, HI emission and HI absorption, and there is substantial CAASTRO involvement in all these programs. CAASTRO has redeployed some of its new postdoctoral appointments toward ASKAP Early Science, and CSIRO will be funding some CAASTRO secondments in 2014 to participate in the commissioning of the Early Science program.

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 9 arcmin. 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. In 2013, the S-PASS team 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 CASS, 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 secure, and construction of the positioner and spectrograph are beginning in 2014, 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, H_0, measure the bulk motion of galaxies to better understand Dark Energy, and together with the WALLABY survey using ASKAP, link the star formation and gas fuelling properties of galaxies to understand galaxy evolution. (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 Ia 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 signal

Institutions: The University of Sydney, European Southern Observatory (ESO)

CAASTRO members are carrying out a project to search for a statistical HI absorption-line signal 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 bandpass calibration, making it possible to search for weaker absorption-lines 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.

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 consortium of the MWA consortium GLEAM aims to survey 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. A substantial time allocation was awarded and the first MWA observations were made in August 2013.

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 Sciences, 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 clumpy Universe on small scales transitions to a homogeneous Universe on large scales, which is a test of the cosmological model. They 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.

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 negotiations on how CAASTRO can contribute to the operational support of LSST which is planned to begin full scientific operations in the 2020 timeframe.

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 $z \sim 6–7$. 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 $z \gtrsim 6–7$. This is a recently observed class 10–100 times more luminous than typical. This class includes pair-instability supernovae, a rare type of supernova explosion for which only 3 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 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 carried out a trial run of the CAASTRO dark matter program using 6dF Redshift Survey data instead of ASKAP data. We have derived a value of the cosmological bias parameter. We also compute a dipole in the velocity field after correction for the velocities due to galaxies.

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 21cm 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 EoR collaboration within the MWA Project. This team will obtain a significant data set with the MWA 128T array to either detect or set limits on the detection of the HI signals from the Epoch of Reionisation. 2013 saw the official opening of the MWA.

The High Time Resolution Universe Survey for Pulsars and Fast Transients

Institutions: Osservatorio Astronomico di Cagliari, CSIRO Astronomy and Space Sciences, University of Manchester, West Virginia University, Max Planck Institute for Radioastronomie, NASA Jet Propulsion Laboratory, Curtin University, Swinburne University of Technology

CAASTRO staff have been involved in the High Time Resolution Universe survey collaboration in 2013. This survey searches the sky using the Parkes Multibeam Receiver and searchers for phenomena with a time resolution of just 64 microseconds. 2013 has been a very successful year with the announcement of the discovery of four Fast Radio Bursts from what appear to be cosmological distances.

Collaborations – Outreach

MWA game design with Quantum Victoria

The CAASTRO Education and Outreach team has partnered up 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 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 to assess their experience afterwards.

Astronomy Weekend and "Astronomer in Residence" at Uluru

In collaboration with Voyages Indigenous Tourism Australia, CAASTRO will be adding to the spectacular outback experience that is Uluru in central Australia by supporting the visit of several CAASTRO researchers. During an astronomy themed weekend, as part of National Science Week 2014, and throughout 2014, for extended periods of time as "Astronomers in Residence", our staff will give presentations about the Universe and offer insights into current avenues of astrophysical research.

Animation library from Swinburne Astronomy Productions

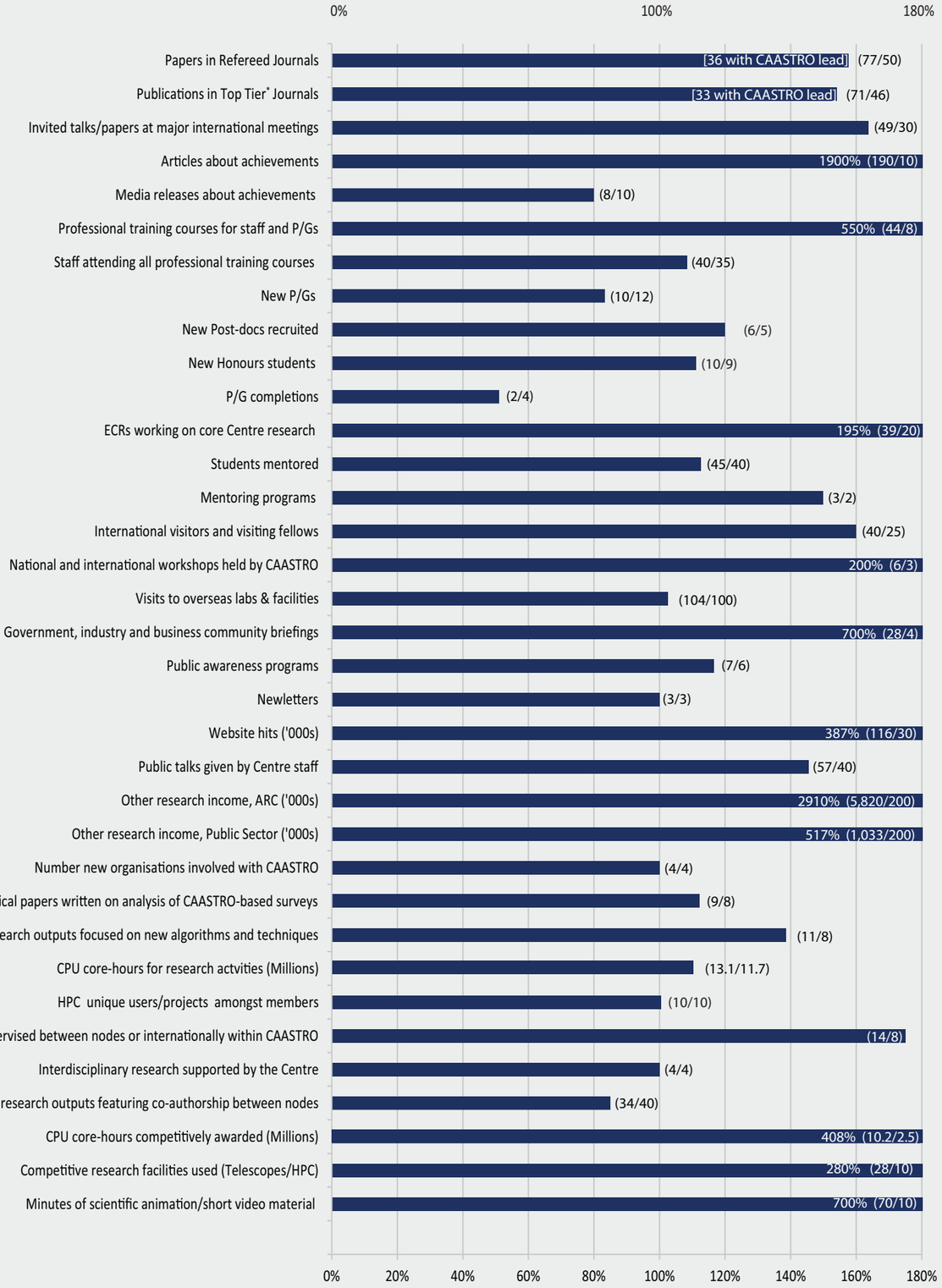
In 2013, CAASTRO intensified its relationship with Swinburne Astronomy Productions to receive a large media library of high quality 2D and 3D animation material for use in CAASTRO presentations and outreach activities. All three CAASTRO themes will be well represented and will be able to draw on this valuable resource of fundamental physical concepts and CAASTRO research-specific topics.

Production of a planetarium show

With the view that CAASTRO all-sky data is most naturally presented on a domed screen, CAASTRO decided to enter a longer term commitment and collaboration with Museum Victoria for the production of a planetarium show. Aiming at a premiere in late 2015 or early 2016, CAASTRO and the team at Melbourne Planetarium are working towards showcasing CAASTRO research results and real data sets for shows in several Australian and overseas locations.

KPI DASHBOARD

January – December 2013



*Nature; Science; Annual Review of Astronomy & Astrophysics; The Astronomy & Astrophysics Review; Physical Review (including Letters) The Astrophysical Journal (including Supplemental Series and Letters); The Astronomical Journal; Monthly Notices of the Royal Astronomical Society (including Letters); Astronomy & Astrophysics (including Letters and Short Communications etc.); Journal of Cosmology and Astroparticle Physics

FINANCIAL STATEMENTS

CAASTRO FINANCIAL REPORT JANUARY - DECEMBER 2013

	2011 INCOME	2012 INCOME	2013 INCOME	2014 ESTIMATED INCOME
ARC Income	$3,000,000	$2,800,000	$3,100,000	$3,100,000
ARC Indexation	$47,431	$153,527	$295,786	$369,118
Node Contributions*	$912,272	$1,039,569	$842,002	$1,057,057
ARC LIEF Grant (ARC)			$740,000	
ARC LIEF Grant (universities and partners)				$417,000
G08-DAAD Joint Research Co-operation Scheme			$10,000	
SIEF John Stocker Postdoctoral Fellowship				$457,437
Other**	$747,294	$13,685	$28,206	$-
Grants won∴	$400,000			
Corrections to 2011˜			-$400,000	
Total Income	**$5,106,997**	**$4,006,781**	**$4,615,994**	**$5,400,612**
Carry Forward	$-	$2,930,552	$2,967,985	$3,037,571
Total Funds Available	**$5,106,997**	**$6,937,333**	**$7,583,979**	**$8,438,183**

* Includes payment by ANU for 2011, $69,539

** Other income includes NSW SLF Grant Part1, scholarship contributions and income from CAASTRO workshops

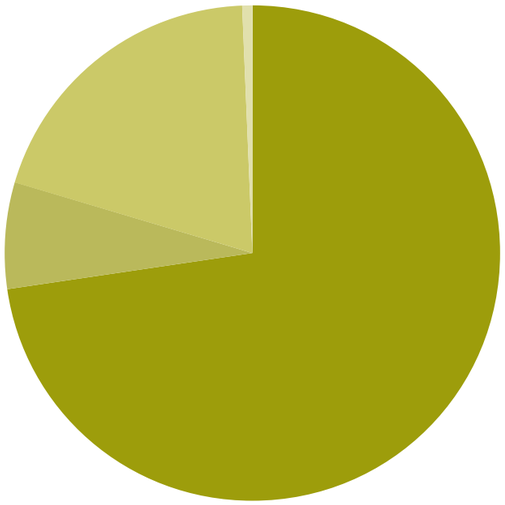
∴ Includes NSW SLF Grant Part II, DIISR Travel Grants and LEIF Grant won by UWA

˜ Adjustment made for 2011 . NSW SLF Grant Part II, DIISR Travel Grant and LEIF Grant should have been listed as 'Grants Won' rather than income.

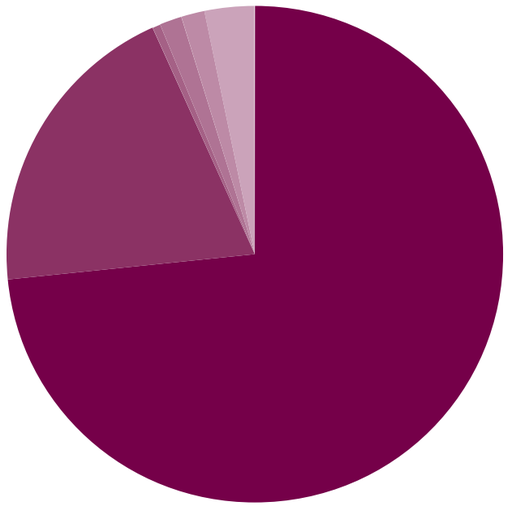
	2011 EXPENDITURE	2012 EXPENDITURE	2013 EXPENDITURE	2014 ESTIMATED EXPENDITURE
Salaries	$1,467,096	$2,807,859	$2,875,061	$3,647,486
Travel, Accommodation and Conference	$363,516	$503,587	$778,788	$609,000
Marketing & Outreach	$124,914	$139,732	$20,336	$175,000
Operations & Maintenance	$103,342	$81,706	$56,535	$109,671
Equipment	$102,993	$145,790	-$59,721	$60,000
PhD Support	$5,709	$101,763	$126,522	$180,000
Research materials/ Experiments	$8,874	$188,911	$5,766	$-
Corrections to 2012"			-$6,879	
ARC LIEF Grant			$740,000	$417,000
G08-DAAD Joint Research Co-operation Scheme			$10,000	
SIEF John Stocker Postdoctoral Fellowship				$457,437
Total Expenditure	**$2,176,445**	**$3,969,348**	**$4,546,408**	**$5,198,157**
Balance	**$2,930,552**	**$2,967,985**	**$3,037,571**	**$3,240,026**

" SKAMP project costs reimbursed to CAASTRO in 2013

2013 Income



2013 Expenditure



In-Kind	
University of Sydney	$882,740
University of Western Australia	$177,441
University of Melbourne	$302,590
Swinburne University of Technology	$793,018
Australian National University	$848,832
Curtin University of Technology	$261,483
CSIRO	$1,072,800
Anglo-Australian Observatory	$1,035,597
Max Planck Institute for Radio Astronomy	$146,696
California Institute of Technology	$134,673
The University of Oxford	$51,170
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 Nucleaire et de Hautes Energies	$149,000
National Computational Infrastructure	$1,000,000
Raman Research Institute	$200,000
Other in-kind income (University of Queensland)	$15,471
Total In-Kind Contributions	**$7,551,056**

GRANTS WON BY CAASTRO MEMBERS IN 2013

ARC Discovery Project
Project Title: Testing Pulsar Emission Models and General Relativity at Pico Arcsecond Resolution
DP140104114
$344,000 over 3 years (2014, 2015, 2016)
Chief Investigator: Jean-Pierre Macquart

ARC Discovery Project
Project Title: Circumnuclear gas in radiogalaxy nuclei
DP140100435
$308,868 over 3 years (2014, 2015, 2016)
Chief Investigator: Jeremy Mould

ARC Discovery Project
Project Title: The Parkes Pulsar Timing Array
DP140102578
$497,000 over 3 years (2014, 2015, 2016)
Chief Investigator: Matthew Bailes

ARC Discovery Project
Project Title: Gravitational Lensing, Gravitational Clustering, and the First Galaxies in the Universe
DP140103498
$346,000 over 3 years (2014, 2015, 2016)
Chief Investigator: Stuart Wyithe

ARC Discovery Project
Project Title: A Fundamental Test of Cosmology - The Orbits & Interactions of Satellite Galaxies
DP140100198
$363,000 over 3 years (2014, 2015, 2016)
Chief Investigator: Christopher Power

ARC Discovery Project
Project Title: How typical is our Local Galaxy Group?
DP140100395
$315,000 over 3 years (2014, 2015, 2016)
Chief Investigator: Aaron Robotham

ARC Future Fellowship
Project Title: In Search of New Gravity: testing advanced theories of gravity with cosmological data
FT130101086
$643,777 over 6 years (2013 to 2017)
Chief Investigator: David Parkinson

ARC Future Fellowship
Project Title: Dead Stars & Monstrous Black Holes - Accretion Powered Feedback in Galaxy Formation
FT1301100041
$632,269 over 6 years (2013 to 2017)
Chief Investigator: Christopher Power

ARC LIEF
Project Title: TAIPAN - a spectrograph to survey the southern sky
LE140100052
$350,000 in 2014
Chief Investigator: Matthew Colless

ARC LIEF
Project Title: A sensitive tip-tilt wave-front sensor for the multi-conjugate adaptive-optics system on the Gemini South telescope
LE140100013
$300,000 in 2014
Chief Investigator: Peter McGregor

ARC LIEF
Project Title: FlashLite: A High Performance Machine for Data Intensive Science
LE140100061
$1,000,000 in 2014
Chief Investigator: David Abramson

ARC DECRA
Project Title: Seeing in the dark: measuring the signature of the early Universe with low-frequency radio telescopes
DE140100316
$325,515 over 3 years (2014, 2015, 2016)
Chief Investigator: Cathryn Trott

ARC DECRA
Project Title: Fast Cubic Gigaparsec Simulations of the Epoch of Reionisation
DE140100940
$394,199 over 3 years (2014, 2015, 2016)
Chief Investigator: Hansik Kim

Private Donation
Professor Walter Stibbs Lecture Series, School of Physics, University of Sydney. Funding of 1-2 visitors to the School of Physics in 2013
$70,000

Other Public Sector
Contribution to BURST project by Swinburne University
$158,700

Other Public Sector
Project Title: SIEF John Stocker Postdoctoral Fellowship
$457,437 over 3 years (2014, 2015, 2016)
Chief Investigator: James Allen

Other Public Sector
Australian SKA Pre-construction Grant: Design of the pulsar timing engine for the SKA Central Signal Processor
$638,000 over 4 years (2013, 2014, 2015, 2016)
Chief Investigator: Willem van Straten

CAASTRO PEOPLE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CAASTRO Executive

1. Bryan Gaensler (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. Brian Schmidt (Dark theme leader)
7. Steven Tingay (Education and Outreach leader)
8. Tamara Davis (Dark theme leader)

Chief Investigators

9. Chris Blake
10. Frank Briggs
11. Matthew Colless
12. Scott Croom
13. Jeremy Mould
14. Elaine Sadler
15. Rachel Webster


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Partner Investigators

16. Lindsay Botten
17. Brian Boyle
18. Warrick Couch
19. Roger Davies
20. Xiaohui Fan
21. Carlos Frenk
22. Andrew Hopkins
23. Simon Johnston
24. Guinevere Kauffmann
25. Michael Kramer
26. Shri Kulkarni
27. Ray Norris
28. Reynald Pain
29. Ue-Li Pen
30. Ravi Subrahmanyan

Associate Investigators

31. Ramesh Bhat
32. Joss Bland-Hawthorn
33. Jamie Bolton


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34. Michael Drinkwater
35. Chris Lidman
36. Jean-Pierre Macquart
37. Martin Meyer
38. Tara Murphy
39. Stephen Ord
40. Chris Power
41. Ashley Ruiter
42. Emma Ryan-Weber
43. Richard Scalzo
44. Ivo Seitenzahl
45. Robert Sharp
46. Stuart Sim
47. Randall Wayth
48. Christian Wolf

CAASTRO Research Staff

49. James Allison
50. Ewan Barr
51. Martin Bell


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52. Julia Bryant
53. Michael Childress
54. Stephen Curran
55. Lisa Fogarty
56. Andrew Jameson
57. Anna Kapinska
58. Eyal Kazin
59. Evan Keane
60. Jun Koda
61. David Lagattuta
62. Emil Lenc
63. Daniel Mitchell
64. André Offringa
65. Se-Heon Oh
66. Pietro Procopio
67. Nicholas Scott
68. Marcin Sokolowski
69. Christopher Springbob


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70. Edoardo Tescari
71. Steven Tremblay
72. Cathryn Trott
73. Fang Yuan

CAASTRO Professional Staff

74. Kim Dorrell (Executive Officer, U. Melbourne)
75. Angela Dunleavy (Administrative Coordinator, Curtin U)
76. Wiebke Ebeling (Education & Outreach Coordinator)
77. Debra Gooley (Finance Officer)
78. Sue Lester (Administration Officer, Swinburne)
79. Clare Peter (Administrative Officer, UWA)
80. Denise Sturgess (Administration Officer, ANU)
81. Michelle Sullivan (Executive Assistant to Director)
82. Kylie Williams (Events & Communications)

CAASTRO Affiliates

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85. Holger Baumgardt
86. Davide Burlon
87. Duncan Campbell-Wilson


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89. Jason Dossett
90. Alan Duffy
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103. Danail Obreschkow
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105. Bart Pindor


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108. Patrick Tisserand
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120. Luke Horsley
121. Fabian Jankowski
122. Andrew Johnson
123. Antonios Katsianis


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134. Jarrod Ramsdale
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139. Jonghwan Rhee
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141. Jennifer Riding


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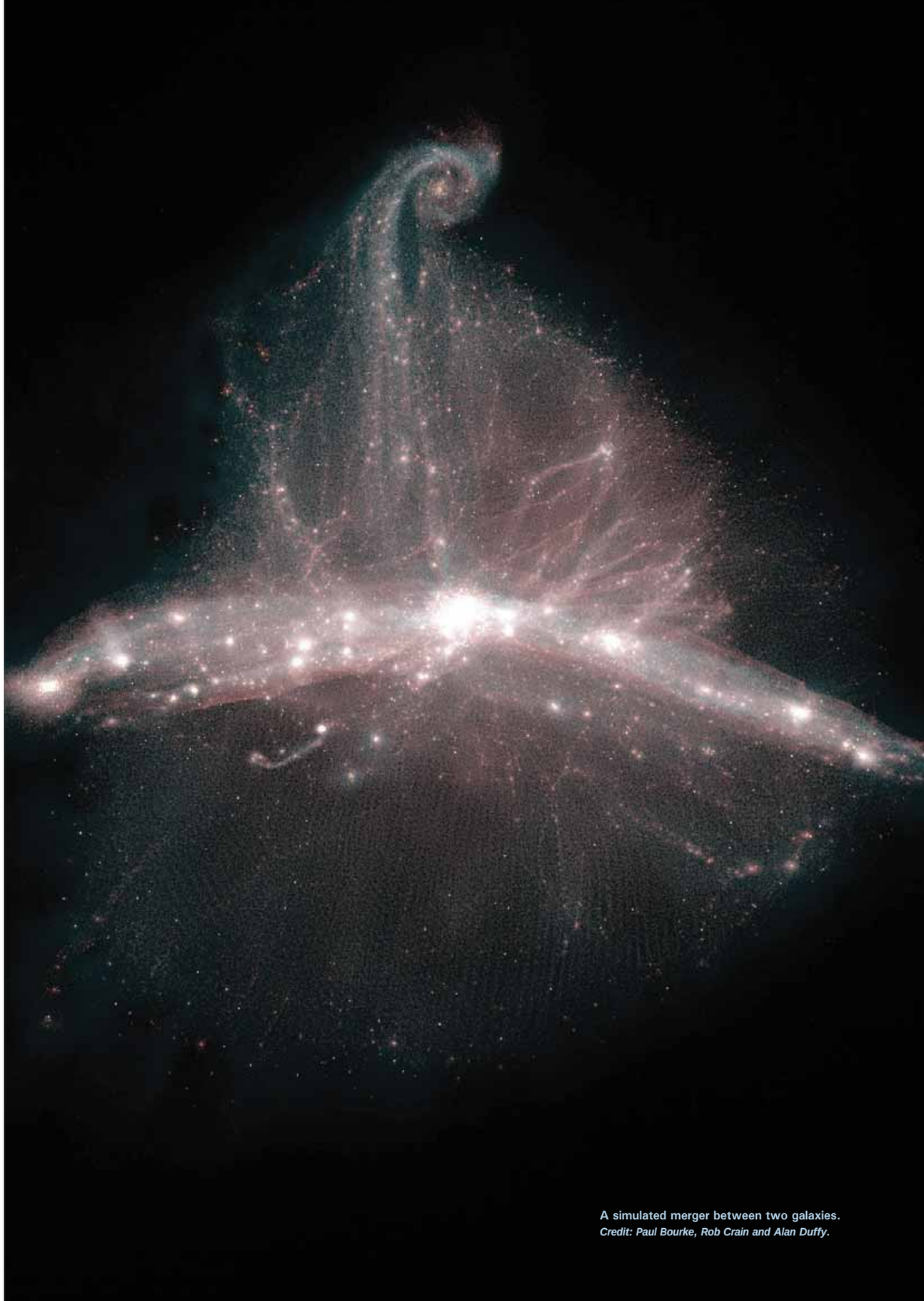
142. Adam Schaefer
143. Paul Scott-Taylor
144. Morag Scrimgeour
145. Kimberly Steele
146. Syed Ashraf Uddin

Not pictured

147. Tina Sallis
(Finance Manager,
Curtin U.)



A simulated merger between two galaxies.
Credit: Paul Bourke, Rob Crain and Alan Duffy.

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