CAASTRO

ARC CENTRE OF EXCELLENCE
FOR ALL-SKY ASTROPHYSICS

TWO

ANNUAL REPORT 2012

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 and Curtin University.

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INTRODUCTION FROM THE CHAIR

DR ALAN FINKEL AM FTSE
CHAIR, CAASTRO ADVISORY BOARD

Galaxies are like minds, with as many stars in the average galaxy as there are neurons in the human brain.

Just like neurons, stars interact with their near and far neighbours in mysterious ways that we are progressively more able to comprehend.

Progress in our understanding on both frontiers comes in increments. At the conclusion of my second year chairing the CAASTRO Advisory Board I am delighted to report that the discovery process is alive and well within CAASTRO and in the home institutions of the participating scientists. The continuing success of CAASTRO is built on the enthusiasm and talent of the students and research staff, guided by strong leadership. My fellow Board members and I are uniformly impressed with the vision and operational skills of the CAASTRO leadership in support of the research agenda and the entire CAASTRO community. The culture of the organisation is very positive and to be admired.

The high level of productivity at CAASTRO is driven by a broad range of collaborations involving scientists from institutions across Australia and around the world. In fact, consistent with its multi-node nature, management only supports new projects when there is cross-node collaboration. These collaborations are assisted by the astute application of financial resources to enable workshops, seminars, video-conferences and necessary travel.

Like every research organisation, CAASTRO faces the challenge of keeping a step ahead of the high-quality investigations undertaken by other researchers around the world. I am pleased to report that CAASTRO meets this challenge by strategically matching research questions to the skills of its staff and students. In addition, the leadership monitors the progress of new observation instruments under construction in Australia to ensure that they can advise students and staff on the alignment of their research questions to the availability of observation time.

At CAASTRO it is more than just research. I have been impressed that at all levels in the organisation there is a commitment to mentoring, skills training, a gender friendly work environment and outreach to the broad community and schools.

The Advisory Board is strongly committed to its role and I take this opportunity to thank my fellow Board members for contributing their time, their experience and their wisdom. I know that the management team at CAASTRO is appreciative. I also take this opportunity to congratulate the executive team, the researchers, the students and the professional staff, led by the Director, Bryan Gaensler, and the Chief Operating Officer, Kate Gunn, for their success in 2012.

I am confident that CAASTRO is well set for further important research outcomes that will contribute to advancing our understanding of the mysterious ways of the Universe.

VISION & MISSION STATEMENT

SKAMP Telescope, The University of Sydney, Bungendore NSW
The University of Sydney

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 and Curtin University 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

CAASTRO had a very strong 2012. A lot of our first year was spent getting things set up, but we knew that the second year had to be all about doing science. And indeed in 2012 we were able to publish some outstanding research results across a wide range of areas. While our research accomplishments are described in detail in the rest of this Annual Report, please indulge me by letting me nominate my own science highlights for the year just past.

In CAASTRO's Evolving Universe theme, our activities for 2012 focused on two major facilities, the Murchison Widefield Array (MWA) and the Sydney-AAO Multi-object Integral field spectrograph (SAMI), both of which are very much now beginning to bear fruit. For the MWA, we published some spectacular 2400-degree^2 images from the MWA's 32-tile prototype, made major progress in developing the algorithms needed for detection of the Epoch of Reionisation, and even used the MWA to detect the reflection of FM radio off the Moon. Our MWA activities culminated in the formal opening of the MWA in outback Western Australia in November 2012, with observing using the full 128-tile array scheduled to commence in July 2013. In 2012 we also published the first scientific results from SAMI, a unique new instrument on the Anglo-Australian Telescope that deploys 13 fused bundles, each containing 61 fibres, across a square-degree field of view. These initial results showcase the power of SAMI to provide simultaneous spatially and spectrally resolved optical images of galaxies, and have led to the serendipitous discovery of a galactic wind in an otherwise ordinary spiral galaxy. Analysis of SAMI data for another 130 galaxies is underway, with commissioning for the full SAMI survey scheduled for early 2013.

Within the Dynamic Universe research program, PhD student Keith Bannister led an innovative search for prompt radio emission from gamma-ray bursts, providing an exciting preview of the much larger data sets that CAASTRO hopes to deliver in coming years. Keith programmed a 12-metre dish to slew almost immediately to the positions of gamma-ray bursts detected by orbiting spacecraft, where the dish then began taking data. This allowed an all-sky search for prompt emission from gamma-ray bursts that was over a thousand times deeper than any previous effort. For two of the nine bursts studied, Keith detected a brief, dispersed, radio pulse, arriving minutes after the gamma-ray burst, suggesting the possibility of a compact central engine that can survive the initial explosion. This intriguing result is now spurring more ambitious follow-up activities, aimed at determining whether such events truly coincide with gamma-ray bursts or can be explained by other mechanisms. Keith was awarded his PhD in June 2012 for his outstanding thesis "Radio Transients: Surveys and Techniques", and remains involved in CAASTRO as an affiliate member as a Bolton Fellow at CSIRO.

In the Dark Universe theme, another one of our PhD students, Morag Scrimgeour, led a milestone paper in which she reported the largest ever study of the transition to large-scale homogeneity in the Universe. One of the fundamental assumptions underpinning most of cosmology is that things are homogeneous on the largest scales. But we know that on smaller scales, the cosmos is filled with inhomogeneity, in the form of people, planets, stars and galaxies. Thus a measurement of the length scale at which the Universe shifts from inhomogeneity to homogeneity is a key test of cosmological models. Morag used data on 200,000 galaxies spread over a volume of 30,000 trillion trillion cubic light years to not only make an accurate measurement of this length scale, but to make the first study of how this scale changes as a function of cosmic epoch. The results were in excellent agreement with the standard "ΛCDM" picture of cosmology, confirming our understanding of the Universe on the largest scales. This result was the subject of a CAASTRO video press release, or "ViPR", which has so far attracted over 3500 hits on YouTube.

CAASTRO now consists of more than 120 people, including 50 postdocs and students. External recognition for this talented team continues to flow: amongst the highlights of our many awards and honours were Brian Schmidt being awarded *The Australian* newspaper's "Australian of the Year", Tara Murphy being named New South Wales Young Tall Poppy of the Year, Steven Tingay being appointed Western Australia's Science Ambassador of the Year, Kate Gunn being named as one of Australia's 100 Women of Influence, and Paul Hancock, JP Macquart and Randall Wayth all being offered prestigious Curtin Research Fellowships. Full details on these and other awards are listed later in the Annual Report. I and the rest of the CAASTRO Executive are very proud when we look at the superb and talented team that we've been able to assemble, and we welcome the many new recruits who have moved to Australia in the last 12 months to join us. In 2012 we were also pleased to welcome the National Computational Infrastructure as a new Partner Organisation, and we look forward to a steadily growing collaboration with them on innovative supercomputing initiatives.

In August 2012 we formally launched our CAASTRO mentoring program, in which every CAASTRO member is paired with a mentor, a mentee, or both. The aim is to provide an extra layer of support for our students and junior researchers, complementing the mentoring that they already receive within their departments and institutes. Initial feedback suggests that this has been a very positive and helpful activity – I thank the CAASTRO Chief Operating Officer Kate Gunn for the initiative and work she has invested in launching and running this program.

Throughout 2012 we expanded our ambitious program of workshops, conferences and sponsorships. Some of the highlights included "Large-surveys in the Multi-Integral-Field-Spectrograph Era" (Sydney, February 2012), "Cosmic Flow in the Rainforest" (Gold Coast, February 2012), "Astronomy with Graphics Processing Units" (Perth, October 2012) and "The Global Epoch of Reionisation Signature (Sydney, November 2012). We concluded the year's activities with the CAASTRO Annual Retreat, held in Cervantes, Western Australia, adjacent to The Pinnacles. In a meeting heavily focused on research results (but with time also set aside for stromatolites and lawn bowls), almost 70 participants presented, brainstormed and strategised our science program. We all emerged enthused by our capabilities and ideas; as one anonymous attendee summarised: "There is awesomeness going on here".

It was also a banner year for our outreach and education programs. The breadth and depth of what we were able to accomplish is remarkable – some highlights included our national partnership with the TafelMusik orchestral tour, the runaway success of our "CAASTRO in the Classroom" initiative, the full house for a visit by the head of NASA, and our wildly popular MWA tile exhibit at the Western Australian Museum. Combined with over 57,000 WWW site hits, 22,000 views on YouTube and 2500 likes on Facebook, there is clear evidence that we have demonstrated a national capability for delivering unique outreach, and that we have established a strong international narrative that explains what we aim to accomplish in our research. I'd like to congratulate Wiebke Ebeling on implementing and coordinating a superb suite of outreach and educational activities, and Greg Madsen for his professional and enthusiastic management of CAASTRO in the Classroom.

I conclude by offering a huge thank you to the many other people who have committed time and ideas into bringing success to CAASTRO throughout 2012. First, many thanks to our extraordinarily engaged and supportive Advisory Board, led by the inspirational Alan Finkel. The relationship of mutual respect and trust that we have established with the Board has allowed some extremely frank and constructive discussions on our progress – I find myself eager to hear what they will recommend at each meeting, so we can set about implementing their suggestions and seeing the rewards. Second, I offer many thanks to our Theme Scientists, Emil Lenc, Chris Springob and Steven Tremblay. The role of Theme Scientist was something new that we created in 2012: Emil, Chris and Steven all eagerly stepped into these positions and made a huge difference to the levels of organisation and cohesion in our research programs. Third, I thank the members of the superb administrative team now in place across CAASTRO, led by Kate Gunn. Kate is an individual of extraordinary energy and vision, and CAASTRO is extremely lucky to have someone of her calibre in charge of all our operations. Finally, I thank the Deputy Director, Lister Staveley-Smith, and the rest of the CAASTRO executive for another year of unflagging support, patience and hard work, which has produced the stunning variety of high-quality activities described in the Report that you're about to read.

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 time line 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, 13.7 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.

Finding Sources in Next-Generation Radio Surveys

CAASTRO astronomers plan to use the Australian Square Kilometre Array Pathfinder (ASKAP) for ambitious new radio surveys such as the Evolutionary Map of the Universe (EMU) and the ASKAP Survey for Variables and Slow Transients (VAST). These surveys will produce far larger and more complex data sets than any previous studies.

"Source finding" in its current form has evolved over past decades to be reasonably reliable, tending only to miss a small fraction of sources. These missing objects are usually identified by hand and then manually added to the source catalogue. However, the images resulting from ASKAP observations will be far too large to inspect by hand. Current source-finding packages are unsuitable, because even if only a small fraction of sources are missed or mis-identified, the resulting outputs will not be useful. For example, the VAST survey will need to extract thousands of sources from survey images every ~5 seconds. A source-finding package with 99% reliability will not only report ~10,000 false variable sources every day, but will similarly miss ~10,000 real variables! For ASKAP, fully-automated software algorithms with increased reliability will be needed to find and characterise the very large number of objects that will be detected.

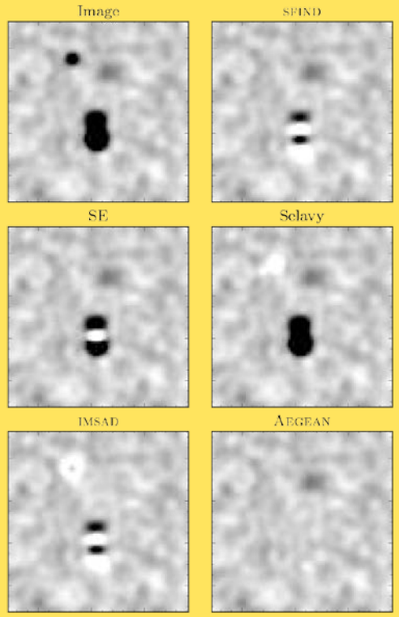
To prepare for these upcoming surveys, CAASTRO researchers Paul Hancock, Tara Murphy, Bryan Gaensler (all from The University of Sydney) and Andrew Hopkins (Australian Astronomical Observatory), along with James Curran (School of Information Technologies, The University of Sydney) quantitatively compared four of the most commonly used source-finding packages used in astronomy: SExtractor, SFIND, IMSAD and Selavy. The team used a simulated data set to evaluate the above four algorithms. A master source catalogue was generated, from which a simulated image of the sky was created. Because the team could control the input catalogue and characteristics of the image, they were able to make precise and definitive statements about the quality of the catalogue derived by each of the four source-finding algorithms.

To assess the performance of each source finder, the team matched the master catalogue with each of the source-finding catalogues. For signal-to-noise ratios greater than 6, all four packages produced catalogues that were more than 99% complete. However, there were two populations that were often missed by one or more of the algorithms: isolated faint sources with a true flux above the detection threshold but an insufficient number of pixels above the threshold due to noise, and sources that contained multiple components within a single island of pixels.

To address the inability of existing approaches to deal with multi-component sources and to improve overall rates of completeness and reliability, the team developed a new source-finding algorithm, "AEGEAN",

based on the application of a Laplacian kernel. AEGEAN was shown to have greatly increased performance over all four existing algorithms considered, and indeed in some cases delivers levels of completeness and reliability close to that expected for an ideal source-finder package. The paper reporting this work was published in *Monthly Notices of the Royal Astronomical Society* in May 2012.

The initial intention for AEGEAN was that it be applied to upcoming surveys with ASKAP. However, AEGEAN has since also been adopted as part of the source-finding pipeline for the Murchison Widefield Array (MWA).



Top Left: A section of the simulated image. Other panels: The fitting residual for each of the source finding algorithms. AEGEAN was the only algorithm to fit all three sources, over both islands

Hancock et al

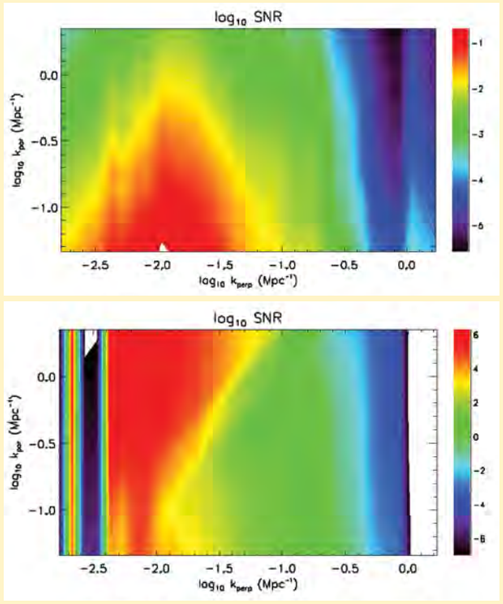
Improving Epoch of Reionisation Data

During the Epoch of Reionisation (EoR), the first sources of ionisation in the Universe converted almost all the neutral hydrogen in the Universe into ionised gas. A key signature of this period is the radio spectral line emission we expect to be produced by the neutral hydrogen that existed before and during reionisation. The structure and redshift of this signal delivers strong constraints on the distribution and nature of those first early ionising sources, and can provide clues about the structure of the very early Universe.

As astronomers begin to search for and study the EoR using facilities such as the MWA, it will be essential to consider the systematic observational biases that will lie in the data, especially given that the EoR signal will be several orders of magnitude weaker than accompanying noise and contaminating signals. Such expected contaminants include bright point sources, unresolved point sources, diffuse galactic synchrotron emission and instrumental effects.

It is often assumed that point sources can be completely removed from the data. However, the reality is that point-source subtraction will inevitably be imperfect. CAASTRO's Cathryn Trott, Randall Wayth and Steven Tingay (all from ICRAR / Curtin University) studied the residuals left in the data by incomplete subtraction of point sources, and quantified the resulting impact on the underlying EoR signal. Their work was published in *The Astrophysical Journal* in September 2012.

The team used information theory to calculate the theoretical limit to which point-sources can be removed from an EoR dataset. At the low radio frequencies required for EoR observations, a key constraint on accurate source subtraction is the effect of the ionosphere. This shifts the apparent location of each point source, and requires source positions to be re-measured every 5 – 20 seconds. The team found that the residual signals from point-source subtraction will not obscure the power-spectrum signal expected from the EoR, but will nevertheless introduce some contamination that needs to be accounted for. Significantly, this research differs from prior studies in that the errors are propagated analytically and the effects of point-source position errors are explicitly included.



Signal-to-noise ratio of EoR statistical estimation assuming a fully-neutral IGM and isotropy, for (a) expected 21 cm signal to MWA thermal noise uncertainty, and (b) expected 21 cm signal to MWA residual signal uncertainty

Trott, Wayth and Tingay

PERFORM

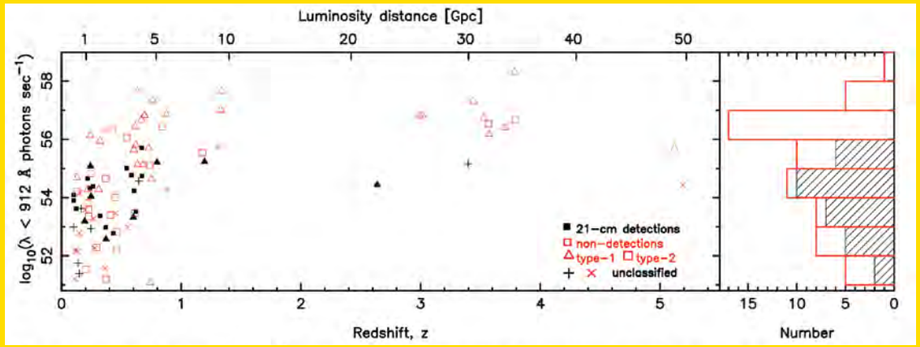
Ionising Cool Hydrogen in the Early Universe

Astronomers looking for cool hydrogen in the early Universe's galaxies with little success can blame supermassive black holes, according to work published by CAASTRO researcher Steve Curran (The University of Sydney). Curran, along with Matthew Whiting (CSIRO Astronomy and Space Science), published a new model in *The Astrophysical Journal* in November 2012, which argues that the intense ultraviolet radiation from these accreting black holes is able to ionise all the surrounding hydrogen gas.

Curran and his colleagues had found in earlier work that there was a lack of 21cm hydrogen absorption features in the hosts of radio galaxies at high redshift, implying that very distant galaxies are lacking in neutral hydrogen gas. This is puzzling, since such distant galaxies (corresponding to times ranging back to just 2 billion years after the Big Bang) should still be undergoing very active star formation, and hydrogen is the fuel for such activity.

For galaxies hosting a supermassive black hole, Curran and Whiting have shown that neutral hydrogen absorption is never detected above a single critical luminosity in the ultraviolet band. This result matches their calculations, which show that all the hydrogen in a galaxy will be ionised for an ultraviolet photon rate above 3 x 10^{56} photons per second. Their model therefore reproduces the observed cut-off in detections of neutral hydrogen, and argues against the possibility that previous non-detections of hydrogen absorption at high redshift were merely due to viewing angle or telescope sensitivity.

When hydrogen gas has been ionised, it is not detectable in the 21cm spectral line that astronomers target, and such gas is also too hot to collapse and form stars. This new work thus has significant implications for searches for redshifted 21cm absorption planned for the Square Kilometre Array (SKA). Curran and Whiting suggest that the SKA will be unlikely to find neutral hydrogen gas in high-redshift radio galaxies and quasars, and that deep continuum radio surveys may be a better initial approach for searching for the fuel for star-formation in the high-redshift Universe.



The rate of ionising (λ < 912 Å) photons versus redshift for the sources searched in 21-cm absorption, obtained from the polynomial fits to the SEDs (Curran et al. 2012). The filled symbols/hatched histogram represent the 21-cm detections and the unfilled symbols/unfilled histogram the non-detections. The shapes represent the AGN classifications, with triangles representing type-1 objects and squares type-2s (+ and x designate an undetermined AGN type for a detection and non-detection, respectively)

Curran and Whiting

Discovery of a Galactic Wind

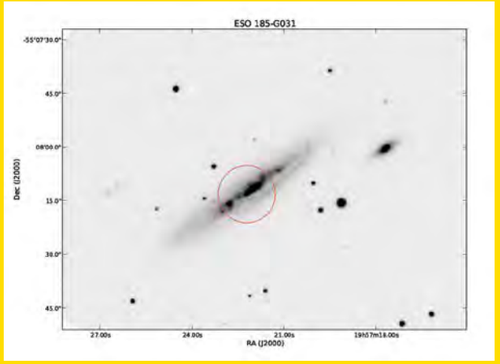
Understanding how galaxies have formed and evolved is a key aim of CAASTRO's Evolving Universe theme. Major surveys over the last decade have studied hundreds of thousands of galaxies, but have used only a single fibre or slit, missing out on the intrinsic complexity within these galaxies.

The Sydney-AAO Multi-object Integral Field Spectrograph (SAMI) is a new instrument developed in collaboration between The University of Sydney and the Australian Astronomical Observatory. SAMI is mounted on the Anglo-Australian Telescope and is the first spectrograph to use hexabundles, in which multiple fibres are fused together to cover a larger area than possible with a single fibre. This allows the spectra of galaxies to be studied efficiently and in detail. In SAMI's case, 13 such hexabundles (with 61 fibres within each) are deployed across a 1- degree^2 field, allowing 13 galaxies to be observed simultaneously, with 61 spectral pixels across each target.

The first SAMI science commissioning run in mid-2011 targeted a single field containing 13 galaxies, selected from the 6dF Galaxy Survey. One particular galaxy, ESO 185-G031 (at a redshift z = 0.016), attracted the attention of CAASTRO affiliate Dr Lisa Fogarty (The University of Sydney), because of interesting kinematic characteristics and emission lines that were immediately seen in the spatially resolved spectra.

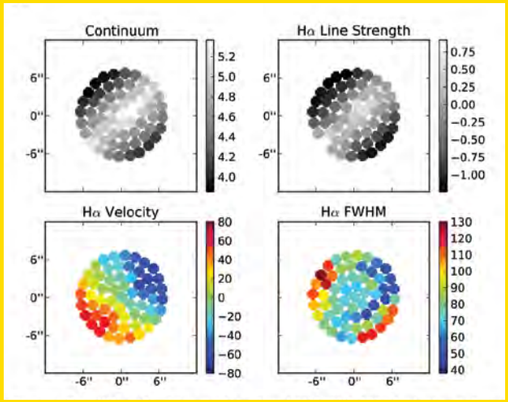
In a paper published in *The Astrophysical Journal* in December 2012, Fogarty and her team (including CAASTRO researchers Scott Croom, Julia Bryant, Matthew Colless and Andrew Hopkins) were able to construct spatially resolved maps of various optical emission line ratios in ESO 185-G031, which provide an indication of the ionisation mechanisms at work. They found that while the disk of the galaxy was dominated by ionisation due to star formation (at a rate of 1.7 solar masses per year), the ionisation source of gas farther away from the plane of the disk was likely to be shock excitation. Combined with analysis of the gas kinematics of ESO 185-G031, the team concluded that they had identified a gas outflow that was not rotating with the disk – i.e. a starburst-driven galactic wind.

The detection of such phenomena can help our understanding of galaxy evolution, since such winds are common in starburst and active galaxies and hence are likely to have an important role in the early Universe when such galaxies were at their peak. Furthermore, this work clearly demonstrates the capability of integral field spectroscopic surveys for undertaking a comprehensive and objective census of outflows in galaxies.



An R-band image of ESO 185-G031 taken with the Maryland-Magellan Tunable Filter (MMTF) instrument on the 6.5-metre Walter Baade Magellan telescope at Las Campanas Observatory. The galaxy is a gas-rich spiral with well-defined arms. The near-side arm is clearly visible running southeast to northwest along the disk. The red circle indicates the footprint of the SAMI hexabundle on the galaxy

Fogarty et al



The Hα kinematics for ESO 185-G031 derived from the pointed observations. A kink is seen in the southwest of the velocity map and a trend towards broader line widths off the plane of the disk is seen in the FWHM map. These are both indicative of a complex kinematic structure comprised of more than one kinematically distinct component, supporting the presence of a wind in this galaxy

Fogarty et al

Calibrating Reionisation Observations Using the Moon

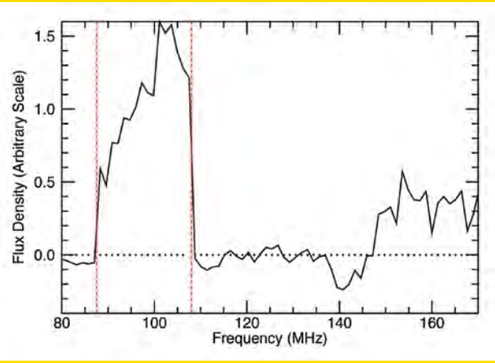
Astronomers searching for the Epoch of Reionisation signal know that it will need careful calibration given the presence of Galactic and extragalactic foreground sources. It has been suggested that one technique for accurate instrument calibration is comparison of the radio signal from the Moon with the background sky brightness.

CAASTRO PhD student Ben McKinley (Australian National University), along with many other astronomers including CAASTRO researchers Frank Briggs, Steven Tingay, Bryan Gaensler, Daniel Mitchell, Ravi Subrahmanyan, Randall Wayth, Rachel Webster and Stuart Wyithe, used the 32-tile prototype of the MWA to observe the Moon for such a calibration test, and to test novel observing modes for the MWA. Their results were published in *The Astronomical Journal* in December 2012.

McKinley and his team demonstrated that three main factors contribute to the radio brightness of the Moon: thermal emission, reflected radio sky background emission, and reflected emission from the Earth. The latter effect was not fully appreciated prior to McKinley's study.

MWA imaging revealed that the Moon was unusually bright in the frequency range 87.5 to 108 MHz, corresponding exactly with the FM radio band and resulted from reflection of terrestrial transmissions. This means that radio emission from the Moon, which moves rapidly across the sky and can thus appear as a transient radio source, will need to be taken into account in the undertaking of all-sky radio surveys. It also complicates plans to use the Moon as a calibration source for detection of the EoR signal.

Interestingly, the strength of the reflected FM radio signal also allows a calculation of how "bright" Earth is in this radio band, and whether this leakage radiation could be detectable by another intelligent civilisation. McKinley found that at the distance of Proxima Centauri, our closest neighbouring star, detection of Earth's FM radio emission would require a telescope far more sensitive than even the SKA, because of the very high sky background at these frequencies. At higher frequencies where the sky is fainter (outside the FM band and outside the range of frequencies at which the MWA operates), leakage radiation should be more readily detectable.



Moon spectrum at 1.28 MHz resolution with an arbitrary flux density scale. The vertical lines denote the FM radio band of 87.5 to 108 MHz

McKinley et al

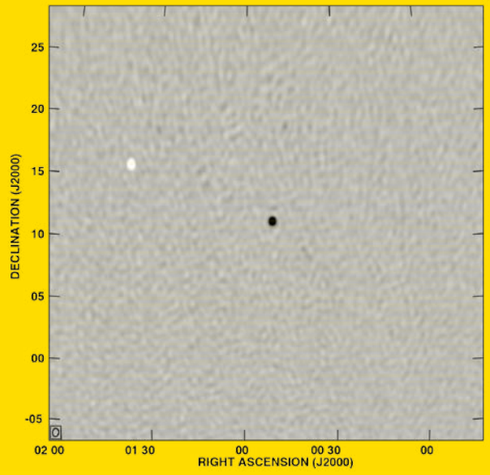


Image slice from the Moon-sky difference cube centred at 99.835 MHz and covering 0.92 MHz of bandwidth (since 28% of the sub-band is flagged). The flux scale of the image is arbitrary at this stage of the calibration process. Darker greyscale indicates higher (positive) flux density

McKinley et al

THE DYNAMIC UNIVERSE

Theme Leader: Professor Matthew Bailes | Swinburne University of Technology

Theme Scientist: Dr Steven Tremblay | ICRAR | Curtin University

The Universe is anything but constant. The physical processes that drive the evolution of the Universe are changing, violent and not fully understood. At radio and optical wavelengths, the changing nature of the sky has been largely unexplored due to the infrastructure needed to handle the data processing.

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. All-sky surveys for radio variability will be conducted using the Murchison Widefield Array (MWA), the Australian Square Kilometre Array Pathfinder (ASKAP) and the Square Kilometre Array Molonglo Prototype (SKAMP). These radio surveys will be accompanied by continuous monitoring of the sky at optical wavelengths with SkyMapper. Combined, these four surveys will allow CAASTRO to study the changing sky over a wider field of view, at higher sensitivity, including some new frequencies, and over a wider range of time scales than ever before.

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.

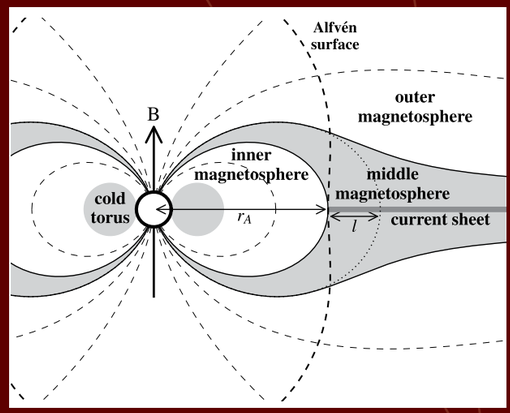
Modelling CU Virginis

The nearby (260 light-years) variable star CU Virginis is a well-studied "magnetic chemically peculiar" star, with a fast rotation period of around 0.52 days. Although these types of stars are known radio emitters, CU Virginis is unique because it produces two 100% circularly polarised radio pulses at each rotation. This polarisation is not consistent with the gyrosynchrotron radiation mechanism usually invoked to explain the radio emission from this class of stars.

In a paper published in April 2012 in *Monthly Notices of the Royal Astronomical Society*, CAASTRO PhD student Kitty Lo presented new radio observations of CU Virginis, and then developed models of the star's magnetosphere to fit her observations.

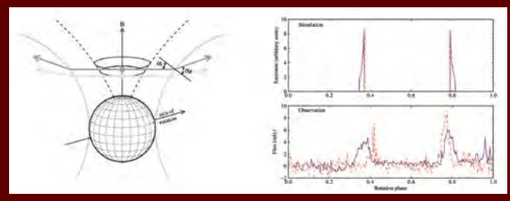
Lo and her team observed CU Virginis at 13 cm and 20 cm wavelengths with the Australia Telescope Compact Array (ATCA) on six occasions, and also used archival ATCA data from 1999 and 2008. This for the first time provided enough frequency coverage to study the frequency dependence of the star's pulse profile in detail, revealing a clear frequency dependence in the time between leading and trailing radio pulses from CU Virginis.

The team explored three models to explain the pulsed radio emission. The first model proposes an electron cyclotron maser as the mechanism for the pulsed radio emission. Although this model predicts the pulse arrival times as seen in ATCA data, it does not account for the width or frequency dependence of the pulses. A second model uses previous modelling of the geometry of the star's magnetosphere. Again, the model did not match the team's observations, with the modelled pulses too wide and containing structures not seen in the data. A final model assumes that radio emission is generated by an electron cyclotron maser directed perpendicularly directed to the local field line (rather than in a hollow cone centred on the field line). Significantly, the model also includes the effect of refraction as the radiation passes through a cold torus (containing trapped material from the stellar wind) within the star's magnetosphere. Results from this model match the observed pulse arrival times and frequency dependence, although the simulated pulses are narrower than what is observed. This discrepancy could be due to the inherent width of the emission beam, variation of the angle of incidence, or turbulent refraction in the cold torus.



Cross-section of the magnetosphere of CU Virginis (not to scale). The magnetic field is assumed to be dipolar within the Alfvén surface (heavy dashes), with equatorial radius r_A. Beyond this radius, field lines (light dashes) are distorted by the stellar wind. Electrons are accelerated in equatorial current sheets beyond the Alfvén radius, and travel along field lines within the middle magnetosphere (shaded), which divides the inner and outer magnetospheres. The parameter *l* describes the extent of the middle magnetosphere, indicating the position of the projection (dotted) of the field line marking its outer boundary within the Alfvén surface. Cooled gas from the stellar wind accumulates in a torus (shaded) near the star

Lo et al.



Schematic diagram (left), and pulse profile of emission (right) for the model of refracted ECM emission in the equatorial plane. The regions in the magnetosphere where emission occurs are marked with solid rings. The emission in the 20 cm and 13 cm bands (dark and light arrows respectively, and solid and dotted lines on the right) is refracted as it crosses the boundary of the cold torus region (dotted). This results in frequency-dependence in the pulse arrival time, corresponding with the observations (bottom right). Note that the refraction in the left panel is exaggerated

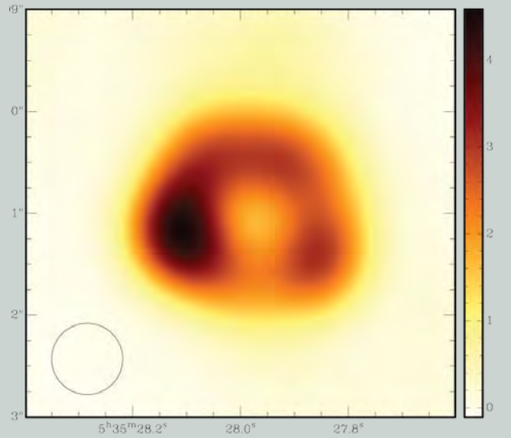
Lo et al

Monitoring Supernova 1987A

It is now more than 25 years since Supernova 1987A in our neighbouring Large Magellanic Cloud first lit up the skies. Since then, the supernova remnant has been studied across a broad range of wavelengths, but observations in the millimetre band have been limited. Such data are of particular interest as they may reveal emission coming from dust or from a theorised young neutron star within the expanding supernova remnant.

CAASTRO's Deputy Director Lister Staveley-Smith and Director Bryan Gaensler collaborated with others in observing Supernova 1987A with the ATCA in 2011 at a wavelength of 3mm, as published in in *Astronomy & Astrophysics* in May 2012. Although Supernova 1987A was first detected at 3mm with the ATCA in 2005, the angular resolution at that time was not sufficient to reveal any significant structure in the source. Since then, the supernova remnant has brightened at these wavelengths as the supernova shock ploughs through surrounding gas, producing synchrotron radiation. The brightening of the source, combined with recent upgrades to the ATCA, enabled the team to successfully resolve Supernova 1987A at 3mm, the highest radio frequency yet at which this supernova remnant has been studied.

The radio shell resulting from these observations resembles the ring seen in early X-ray images, and sets an upper limit on the radio emission emanating from any dust or pulsar wind nebula in the centre of the supernova remnant. The team is now pursuing even higher frequency observations of Supernova 1987A using the Atacama Large Millimetre/submillimetre Array (ALMA).



Diffraction-limited Stokes-I continuum image of SNR 1987A at 3 mm from observations made on 2011 June 30, July 1 and August 2. The image is restored to a 0.7″ circular beam (plotted in the lower left corner). The off-source r.m.s. noise is ≈ 0.5 mJy beam^{-1}

Lakićević et al

A Uniquely Located Magnetar Candidate

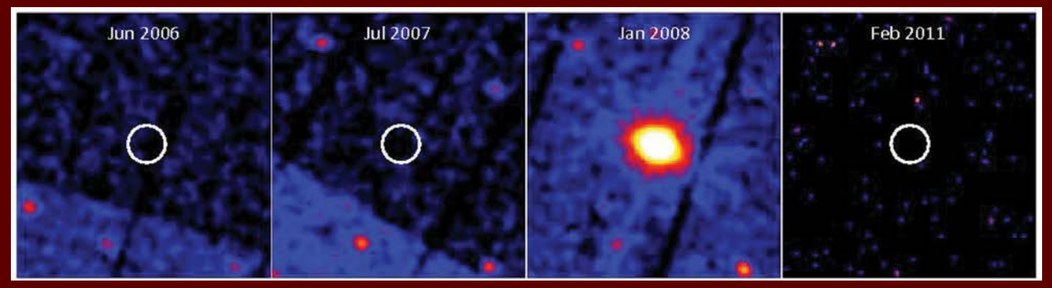
Joseph Callingham, a vacation student working with Sean Farrell and Bryan Gaensler at The University of Sydney, led a study of an unusual transient X-ray source, detected in January 2008 in a survey of the nearby galaxy M31 (the Andromeda Galaxy) with the XMM-Newton X-ray space observatory. The position of the source, 2XMMi J003833.3+402133, is coincident with the outer edge of M31, and another team of astronomers had previously concluded that this object was a probable X-ray binary in M31.

However, Callingham's new research, published in *The Astrophysical Journal* in September 2012, argues that 2XMMi J003833.3+402133 may not be an X-ray binary and may not be in M31. The team's analysis of the X-ray spectrum, the behaviour of the transient itself and the lack of an optical counterpart are characteristic of magnetars. What's more, the data suggest that the magnetar is not then in M31, but instead is in our own Milky Way Galaxy.

In addition to the XMM-Newton X-ray detection, the team searched for the object in other archival X-ray data from XMM-Newton, ROSAT, Chandra and Swift, and also obtained new observations of the field with Swift in 2011, all without success in detecting the source. Similarly, no detection was made on images taken in 2008 with the Canada-France-Hawaii Telescope or in past radio surveys.

The magnetar class of neutron star, characterised by very strong magnetic fields and relatively slow rotation rates, is a small known population at present, with only 20 confirmed candidates and 3 suspects, and all are believed to be young objects. Two magnetars are known to lie in the Magellanic Clouds, the rest are in the Milky Way's plane. Assuming that this magnetar was also formed in the Galactic plane and has a typical magnetar velocity, the current location of 2XMMi J003833.3+402133 in the sky implies a distance from Earth of just 40 light-years. This proximity is not only improbable for such a rare population, but would imply an X-ray luminosity far lower than for any other magnetar. On the other hand, if the magnetar is thousands of light years from us like other Galactic magnetars, then its luminosity would be in keeping with other known magnetars, but it would then be located much higher off the Galactic plane than where magnetars are normally found.

Such a location raises puzzling questions about the magnetar's origins. The team proposes two possible origins – either the progenitor was a massive star that went supernova in the Galactic plane and the magnetar is now very old with a very weak magnetic field, or the progenitor could have been a massive runaway star that was ejected out of the Galactic plane and then subsequently went supernova near the magnetar's current location. Further X-ray observations of the candidate can confirm the magnetar nature of the source and help distinguish between the different proposed scenarios for the object's nature and origin.



X-ray images of the field of 2XMMi J003833.3+402133 taken with XMM-Newton (panels 1 to 3 from the left) and Swift. The white circle indicates the position of XMM J0038+40 with a radius of 30". The XMM-Newton images span the energy range of 0.2 – 12 keV, while the Swift image spans 0.3 – 10 keV. A Gaussian smoothing function with a kernel radius of 3 pixels was applied to all images

Callingham et al

Searching For Radio Pulses from Gamma-Ray Bursts

Gamma-ray bursts are the most energetic events known in the Universe. There are many aspects of gamma-ray burst physics that are not yet well understood, some of which could be directly probed by the detection of prompt radio emission from these events.

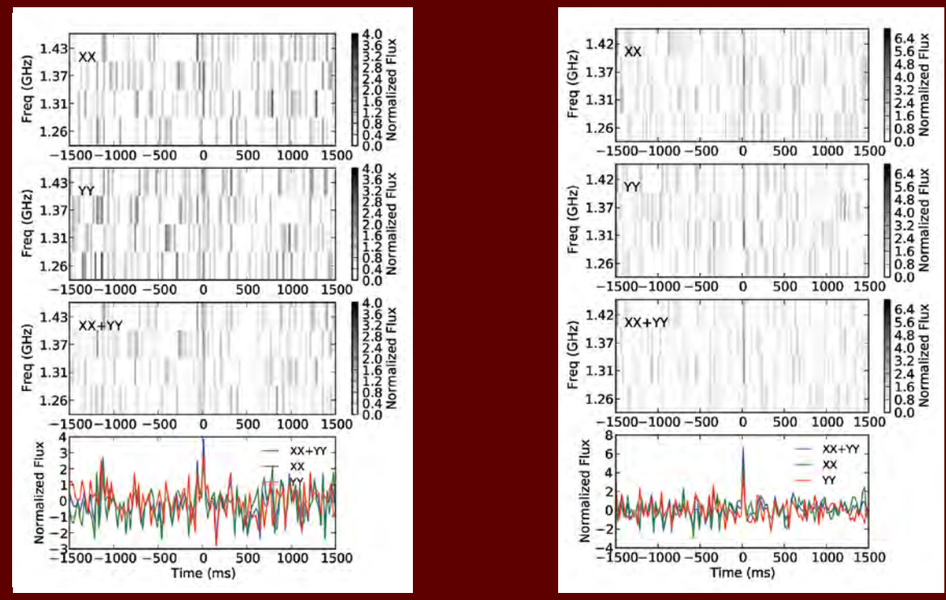
Former CAASTRO PhD student (and now CAASTRO affiliate researcher) Keith Bannister has performed an innovative new search for prompt radio emission from gamma-ray bursts, which he published in *The Astrophysical Journal* in September 2012. Bannister and his team used a 12-metre test antenna at Parkes to slew automatically to the reported position of any discovered gamma-ray burst. The dish was typically able to begin taking data within 200 seconds of the gamma-ray burst's detection. Over a period of 10 months, the system triggered on nine confirmed gamma-ray bursts detected by the Swift satellite. No radio signal was seen for seven of these bursts, but observations of the other two each resulted in the detection of a single dispersed radio pulse at high significance, a few milliseconds in duration and occurring several minutes after the initial gamma-ray signal.

Most gamma-ray bursts are thought to result from the collapse of a massive (greater than ten solar masses) star. Under this model, such a collapse produces a black hole or a magnetar. The accretion disk that forms around this central engine leads to jets, gamma-ray emission and shocks permeating out into the surrounding medium.

Bannister's measurements of the energy from the observed radio pulses places them within the total amount of energy expected to be released from the collapse of such a massive star, while the narrow width of the radio pulses suggest that they emerged from a source close to the black hole or magnetar that had formed from the massive star collapse.

Two significant issues arising out of these results are the relatively long time interval between the initial gamma-ray burst and the subsequent radio pulse, and the fact that only one radio pulse was observed for each gamma-ray burst. Assuming that the lack of multiple radio pulses per source was not merely due to a lack of sensitivity, these facts suggest that the initial stellar collapse formed a magnetar, which existed for a few minutes before further collapsing into a black hole. In this interpretation, the initial event produced the gamma-rays and the final delayed collapse generated the radio signal.

There remains the possibility that neither radio pulse was physically associated with a gamma-ray burst, but rather was an instrumental effect or other unrelated astrophysical phenomenon. In this case, the experiment still provides strong upper limits on the prompt radio emission from gamma-ray bursts, at sensitivities far superior to previous such experiments. Future work will focus on coincidence detection, using two separated telescopes to simultaneously observe the same targets.



Details of the 6.2σ pulse detected 1076 seconds after GRB 100704A (left) and 524 seconds after GRB 101011A (right). The top three panels are the dedispersed time series of 4 frequency channels spread across the band. The pulse appears clearly in both polarisations (the top 2 panels) and in the sum of the two polarisations (third panel). The bottom panel is the time series where all the frequency channels have been summed. The origin of the time axis is the pulse arrival time (T_{pulse})

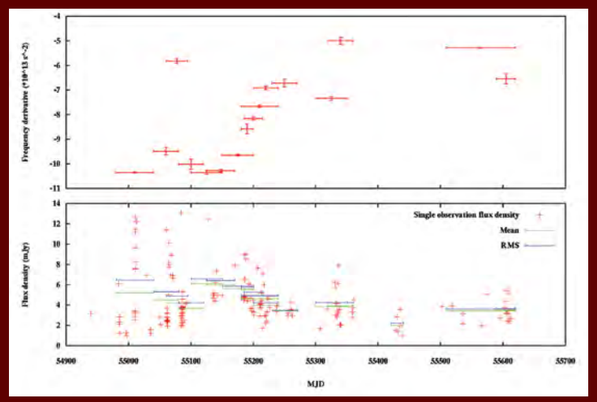
Bannister et al

Studies of the Radio Magnetar PSR J1622-4950

In 2010, astronomers reported the discovery of the pulsating radio magnetar PSR J1622-4950 as part of the High Time Resolution Universe survey for pulsars and fast transients using the 64-metre Parkes radio telescope. One of only three known magnetars known to emit radio waves, PSR J1622-4950 was the first such source to be discovered at radio wavelengths (rather than in a radio study of an X-ray source).

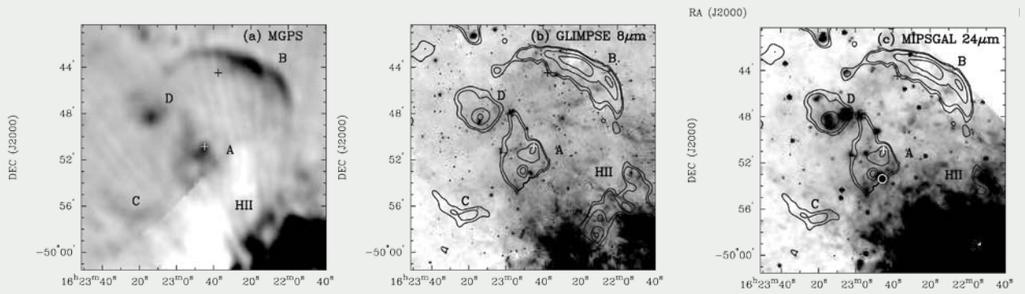
CAASTRO researchers were involved in two separate studies of PSR J1622-4950 in the past year. The first, published in *Monthly Notices of the Royal Astronomical Society* in April 2012, was led by CAASTRO student Lina Levin. Her work with Parkes revealed that the peak flux density of radio emission from PSR J1622-4950 had halved since the magnetar's discovery a few years earlier, and that there were large variations in the rate of spin-down. Model fitting revealed that the magnetic and rotational axes of PSR J1622-4950 were almost aligned, with the line of sight remaining in the emission beam for large parts of the magnetar's rotation period. This may explain why only three magnetars have been seen so far at radio wavelengths.

The second study, published in *The Astrophysical Journal* in May 2012, was from a large team that included Bryan Gaensler, Matthew Bailes, Ramesh Bhat and Michael Kramer. Their work analysed pre-discovery observations of PSR J1622-4950 taken with the Chandra X-ray Observatory in 2007 and 2009 and new observations from 2011 using the XMM-Newton X-ray satellite, along with radio data from ATCA and Molonglo. The X-ray data showed that the X-ray flux from PSR J1622-4950 had decayed by a factor of 50 over 4 years, suggesting that this source has been recovering from a flare or outburst that occurred in early 2007. The ATCA data also showed strong variability, including a possible radio flaring event occurring 1.5 years after the 2007 X-ray outburst. Radio imaging with Molonglo showed that PSR J1622-4950 sits near a faint radio arc, G333.9+0.0, which appears to be a previously unidentified supernova remnant, possibly associated with PSR J1622-4950. To date, few such associations have been found, yet they are a valuable linkage as supernova remnants provide constraints on the properties and environment of the associated magnetar.



Top plot: Variation of frequency derivative with time for PSR J1622-4950. The error bars in the x-range indicate the time span of the included Times of Arrivals (TOAs). The large variations in the value of the frequency derivative indicate changes in absolute value and sometimes also in sign of the second derivative

Bottom plot: Variation of flux density at 1.4 GHz with time.
Levin et al



Radio and infrared images of the region surrounding PSR J1622–4950. Each image is centred on the position of PSR J1622–4950, indicated by the white "+" symbol. Nearby radio sources are labelled A, B, C, and D, and the HII region, G333.6–0.2, is also indicated. The black contours in panels b and c show the MGPS1 0.005, 0.01, 0.03 and 0.05 mJy per beam radio emission levels. The nearby pulsar, PSR J1622–4944, is indicated by a black "+" symbol. a) The surrounding region as seen in the MGPS1 radio survey at 843 MHz and at a resolution of 43". b) The greyscale is the surrounding region as seen in GLIMPSE at 8 μm at a resolution of 1.2". c) The grayscale as seen by MIPSGAL at 24 μm at a resolution of 6". The white circle indicates the position of IRAS 16190–4946 with a radius of 23", equivalent to its major axis position uncertainty.
Anderson et al

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 96% 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 nearby Type Ia supernovae all over the sky. Statistics on the relative brightness of these explosions compared to more distant supernovae 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.

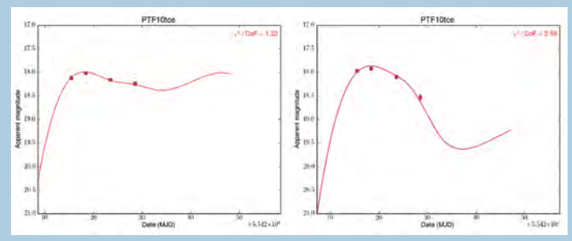
Second, we are performing all-sky measurements of large numbers of galaxies in both the radio and optical bands, in order to derive precise estimates of their distances, velocities and 3D distributions in space. Combining this information with a substantial new body of simulations and theoretical tools, we aim to measure the velocity field of galaxies out to 10% of the Hubble radius. 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 "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.

Type Ia Supernovae as Cosmological Standard Candles

Type Ia supernovae are used widely as standard candles in visible light for measuring cosmic distances. However, it has been suggested that these supernovae may be even more accurate distance indicators in the near-infrared: there is less dust extinction in the infrared than at optical wavelengths, and current models indicate that infrared data also have a smaller intrinsic dispersion in their peak magnitudes. However, previous attempts to use infrared observations of Type Ia supernovae as reliable for distance markers have been limited by the lack of data on supernovae distant enough to be in the Hubble flow (where their redshifts are dominated by the expansion of the Universe) as opposed to being affected by peculiar velocities.

A new study involving CAASTRO researchers Chris Lidman, Stuart Wyithe and Jeremy Mould, published in *Monthly Notices of the Royal Astronomical Society* in September 2012, has looked at 12 Type Ia supernovae discovered in 2009-2010 that fell in the redshift range $0.03 < z < 0.09$ (i.e. at a sufficient distance to be in the Hubble flow). These supernovae were all re-observed with the HAWK-I camera on the European Southern Observatory's 8.1-metre Very Large Telescope and with the NIR Imager and Spectrometer on Gemini Observatory's 8.2-metre Gemini North Telescope. Reference images were also taken around a year after the initial observations so that the host galaxies could be subtracted, leaving just the light of the supernovae.

Through analysis of the near-infrared light curves, the team found that the intrinsic scatter in the supernovae's peak luminosities was extremely small, allowing distance measurements with an accuracy of 4%, arguing that Type Ia supernovae observed in the near-infrared are the best available standard candles for cosmology. The precision of this approach provides new opportunities for measurements of both the expansion history of the Universe and peculiar velocities of nearby galaxies.



The team fitted the "Flexible Light-Curve Infrared Template" (FLIRT) to the H-band (left) and J-band (right) light-curves of the supernova PTF10tce in order to find the supernova's light-curve maxima
Barone-Nugent et al

Large-scale Homogeneity in the Distribution of Galaxies

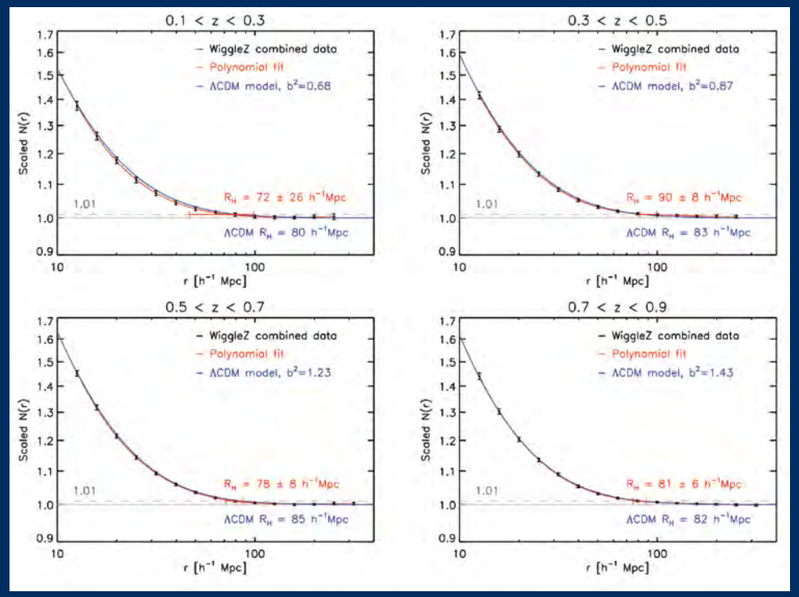
ΛCDM cosmology is based on the key assumption that the Universe is homogeneous on very large scales. By "homogeneous", it is meant that statistical properties such as density are the same everywhere. Under this assumption, the Universe can be described by the Friedmann-Robertson-Walker (FRW) metric (a solution of Einstein's general relativity field equations), which allows the distances to galaxies to be determined from their redshifts.

Such a fundamental assumption needs to be verified observationally, and measurements need to be made of the physical scale at which the Universe transitions to being homogeneous. Indeed in the last decade there has been a debate as to whether or not the Universe is truly homogeneous at large scales. Observations of the cosmic microwave background demonstrate the presence of large-scale homogeneity in the early Universe, but galaxy surveys have given mixed results for the homogeneity of the nearby Universe, due to complicating factors such as the relatively small survey volume.

To better understand the degree to which the Universe is homogenous, CAASTRO PhD student Morag Scrimgeour (ICRAR | UWA) along with CAASTRO researchers Tamara Davis, Chris Blake, Lister Staveley-Smith, Matthew Colless, Warrick Couch, Scott Croom, Karl Glazebrook and a large international team, has used the WiggleZ Dark Energy Survey to make the largest-volume measurement to date of large-scale homogeneity in the distribution of galaxies. The work was published in *Monthly Notices of the Royal Astronomical Society* in September 2012.

WiggleZ is a recently completed spectroscopic galaxy redshift survey conducted with the 3.9-metre Anglo-Australian Telescope. Some 239,000 redshifts were measured, of which 179,599 were in regions suitable for Scrimgeour's study, covering some 1000 square degrees of sky in 7 regions. WiggleZ covered both a larger volume and a higher redshift range than any previous galaxy redshift survey.

Scrimgeour and her team measured the "count-in-spheres" (the number of galaxies within a sphere of a given radius centred on a galaxy) and their "fractal dimension" (used to describe the clustering of a point distribution), and found that there was a transition from a clustered distribution on small scales to a homogeneous distribution on scales above approximately 70 Mpc/h at a redshift $z = 0.2$, in excellent agreement with the predictions of ΛCDM. The team also demonstrated the robustness of their results against systematic effects from the survey selection function by repeating their analysis using a suite of fractal mock catalogues and N-body simulations. Overall, the results provide very strong agreement with the FRW-based ΛCDM model.



Scaled counts-in-spheres $N\,(< r)$ for the combined WiggleZ data in each of the four redshift slices (black error bars). A ΛCDM model with best-fitting bias b^2 is shown in blue. A 5th-degree polynomial fit to the data is shown in red. The red error bar and label show the homogeneity scale R_H for the galaxy distribution, measured by the intercept of the polynomial fit with 1.01 (1 per cent away from homogeneity), with the error given by lognormal realisations. This scale is consistent with the ΛCDM intercept with 1.01, labelled in blue

Scrimgeour et al

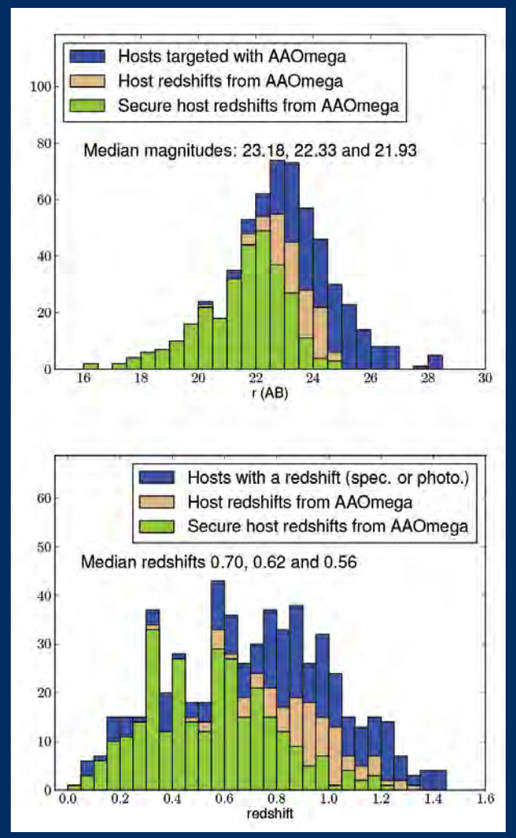
Measuring Large Numbers of Supernova Host Redshifts

In studying Dark Energy and the accelerating Universe, observations of distant supernovae are paramount. The original discovery of the accelerating Universe was based on just a few dozen supernovae, while currently the largest data set of distant supernovae is the Supernova Legacy Survey (SNLS), a 3-year program that discovered 252 Type Ia supernovae. The new Dark Energy Survey (DES, being conducted at the Cerro Tololo Inter-American Observatory in Chile) is expected to discoverer around 4000 supernovae suitable for studying the effects of Dark Energy. However, to then spectrally confirm (and also determine the distances of) these 4000 supernovae is estimated to take around 4000 hours of 8-10 metre-class telescope time (i.e. approximately 1 hour per supernova). What's more, for a supernova to be confirmed spectroscopically, it typically needs a spectral measurement within one week of maximum light. For this reason, it may be impractical to obtain direct spectroscopic confirmation of every supernova candidate discovered by DES.

CAASTRO Associate Investigator Chris Lidman (AAO), along with a team of other astronomers including Karl Glazebrook, Jeremy Mould and Reynald Pain, has considered an alternative approach to resolve this problem, in which one measures the redshifts of the host galaxies of supernovae rather than the redshifts of the supernovae themselves. The underlying principles are that preliminary classification of each supernova is made using its multi-colour light curve, and that the host galaxy redshift is obtained long after its supernova has faded.

Using the 2dF fibre positioner and the AAOmega spectrograph on the Anglo-Australian Telescope, the team observed 698 galaxies that had had supernovae discovered in them during the first three years of the SNLS. The targets were selected based on an original catalogue of 1483 candidate supernovae (as flagged by their light curves), which were prioritised into five categories, the highest category being those that had been photometrically designated as Type Ia supernova but did not have a measured redshift.

Because many galaxies fell into the same wide field of view of 2dF, the strategy of observing these galaxies rather than their supernova enabled multiple redshifts to be determined simultaneously. Lidman obtained redshifts for about 60% of the galaxies targeted (most of the galaxies for which a redshift was not measured were fainter than 23rd magnitude), demonstrating this approach as an efficient new way of obtaining large numbers of supernova redshifts. The team's work has been accepted for publication in *Publications of the Astronomical Society of Australia*.



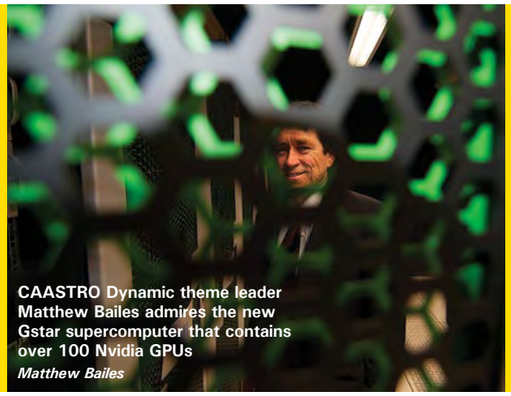
Histograms of the number of objects plotted as a function of magnitude (above) and redshift (below). The blue, green and tan histograms represent all objects targeted with AAOmega, all objects with secure AAOmega redshifts (quality flags 4 or 5), and all objects with either a secure AAOmega redshift or a probable one (quality flags 3, 4 or 5). The median magnitudes and redshifts of objects in the blue, tan and green histograms annotate each figure

Lidman et al

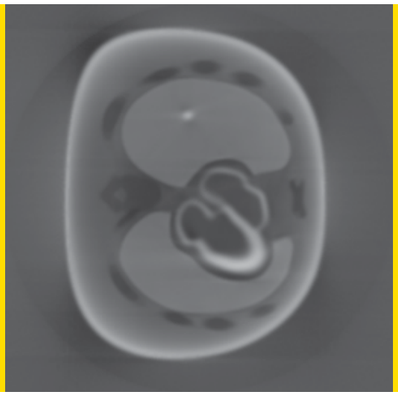
DISCOVER

CASE STUDIES

The upgraded Sydney AAO Multi-Object Integral Field Spectrograph (SAMI) mounted on the Anglo-Australian Telescope.
SAMI team



CAASTRO Dynamic theme leader Matthew Bailes admires the new Gstar supercomputer that contains over 100 Nvidia GPUs
Matthew Bailes



Transaxial slice through a noise-free simulated Positron Emission Tomography (PET) scan, showing a lung lesion and the myocardium
Cathryn Trott

Interdisciplinary Research Case Study

CAASTRO AND NVIDIA

Professor Matthew Bailes
(Swinburne University of Technology)

A revolution is occurring in radio astronomy signal processing. Until recently, radio astronomers have been able to focus the signals from many antennas into receivers, but have been unable to cope with the deluge of information to maximise the scientific return. This is now changing, and the unlikely ally in this fight of data vs science are the companies behind computer gaming.

A gamer's screen comprises of millions of pixels of information, and to create the most realistic gaming experience, engineers at Nvidia corporation have been investing billions of dollars into creating the highest performance graphics cards to individually process information in a massively parallel way.

The fundamentals behind computer graphics, Fourier transforms and very fast computation are shared by radio astronomers. So the mass production of inexpensive computer games cards has made possible a new computational engine for radio astronomers, the Graphics Processing Unit, or GPU.

In CAASTRO we have been looking at ways to partner with Nvidia to deliver signal processing engines to process the raw voltages digitised by our instruments. The first foray into the use of GPUs commenced in 2009 with data from single dish telescopes, but CAASTRO's Steve Ord at Curtin has now extended into multi-element arrays like the Murchison Widefield Array where the cards use the correlator software developed by Harvard's Mike Clark (now at Nvidia) to process all 128 tiles.

The GPUs consume more power per flop than more traditional radio astronomy correlators, but their "time to market" is unbelievably short and the ease of reprogramming them has led to their rapid adoption around the globe in new instruments and different scientific applications.

The release of Nvidia's new "Kepler" line of GPUs, including the K10, has seen the Gstar supercomputer at Swinburne University of Technology expand its computational capacity to an amazing 400 Teraflops, and is being used to search for accelerated neutron stars by CAASTRO and its international collaborators at CSIRO, Manchester, Cagliari and the MPIfR in Bonn as part of the High Time Resolution Universe survey.

In 2012, Swinburne's lead software engineer, Andrew Jameson, was invited to Silicon Valley to take part in a special industry briefing from Nvidia to describe their future roadmaps for the GPU, and to see how they can partner with CAASTRO to work on GPU designs for the Central Processing Engine for the Square Kilometre Array.

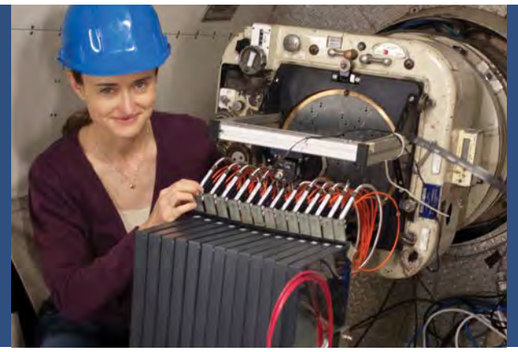
Interdisciplinary Research Case Study

IMPROVEMENT IN LESION ESTIMATION TASKS USING SIMULTANEOUS MRI/PET IMAGING

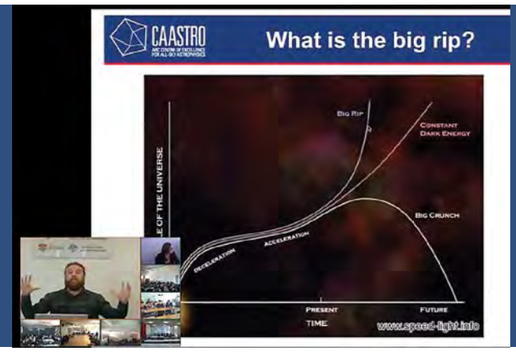
Dr Cathyrn Trott and Dr Steven Tremblay
(ICRAR | Curtin University)

Medical imaging is entering a new era, where the limited information provided by a single imaging modality (e.g., MRI, PET) is being enhanced by complementary information from dual-modality scanners. The combination of Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI) into a single scanner provides timely diagnostic information to the clinician, as well as providing a unique combination of anatomical and physiological information.

The nuclear medicine physics group at Massachusetts General Hospital (MGH) has developed an algorithm to reconstruct the information from these imaging modalities in a way that uses the information optimally. We have provided the theoretical counterpart to this work, demonstrating the improvement in measurement performance, and hence diagnostic utility, of combining these imaging modalities into a single scanner. The tools we used are the same as those we are applying to radio astronomical datasets. The group was composed of experts in imaging algorithms, information theory, and PET and MRI scanners, and has direct implications for scanners being tested at MGH.



Julia Bryant and SAMI – the next advance in galaxy spectroscopy
Julia Bryant



Martin Bell uses the CAASTRO video-conferencing system to conduct a "CAASTRO in the Classroom" session
Greg Madsen

Interdisciplinary Research Case Study

FABRICATING FIBRE BUNDLES

Dr Julia Bryant (The University of Sydney)

Over the last few years, the School of Physics at The University of Sydney has developed new fibre imaging bundles for astronomy that have revolutionised spatially-resolved spectroscopy of galaxies. The success of these 'hexabundles' has been demonstrated on-sky in the Sydney-AAO Multi-object Integral field spectrograph (SAMI).

In our astrophotonics laboratories, we have an advanced fibre processing facility that is being used to fabricate new, updated and improved hexabundles. We use optical fibre that has a 105-micron core surrounded by a 10-micron thick glass cladding. The process involves etching the cladding down to a thickness of only 5 microns, and fusing the fibres together at high temperature to form a bundle of 61 fibres, nearly 1mm across. This bundle can form a 15-arcsecond wide image of a galaxy on the sky, while also giving 61 individual spectra at the location of each fibre across the galaxy.

The major breakthrough in this technology lies in the ability to now make hexabundles without the crippling throughput losses due to focal ratio degradation (FRD) that affects fibres when they are distorted by a fusing process. A further advantage is that the fill-factor is higher than can be achieved by simple glued bundles, giving an improvement in the spatial sampling across a galaxy. 13 of these hexabundles have been completed in our laboratories, and were installed on the SAMI instrument in January 2013.

Instruments like SAMI and HECTOR are the next advance in galaxy spectroscopy from previous multi-fibre spectroscopy, which has used robotic positioners to put single fibres on galaxies. Now the single fibres can be replaced by hexabundles. Spectra at many positions across a galaxy can then be used to determine, for example, the distribution of star formation, stellar and gas dynamics, and evidence for interactions, giving a clearer picture of galaxy formation and evolution in different environments.

Interdisciplinary Research Case Study

OPAL GROWTH AND GLOBAL CLIMATE

Dr Cathryn Trott and Dr Steven Tremblay (ICRAR | Curtin University)

Growth of opal crystals is dependent on atmospheric properties, with availability of nutrients and temperature two major drivers of growth rate. We can measure the growth rate of opals by radiological dating of minute traces of uranium within the crystal. A group of Curtin geologists made these measurements for a set of opal crystals from Western Australia, in the hope that they could link growth rates with other measures of climatic conditions. CAASTRO was approached by the group to provide a rigorous analysis of the data. The combination of the geologists' expertise in radiological dating and our analytic skill set yielded a successful result, which is suggestive of a link between the growth rate and global temperature variations.

National Innovation Priority Case Study

ENCOURAGING A CULTURE OF COLLABORATION

Professor Lister Staveley-Smith (ICRAR | University of Western Australia)

Astronomy and astrophysics have evolved from an activity involving small groups of researchers operating in a laboratory/University environment to an activity involving large research teams using expensive telescope and computing facilities in a multinational environment. For example, the ASKAP and MWA telescopes, in which CAASTRO researchers play an important research role, have teams of many researchers. These combined facilities represent a $200M+ investment and will be used by researchers from institutes in Australia and other institutes internationally.

Communication in an environment where teams are large, individuals may not know each other, distances are large and time zones are problematic is challenging. Research organisations such as CAASTRO have limited travel budgets. For example, we can only afford to host one major international meeting each year and one retreat for Australian investigators each year.

Therefore, a remarkably successful addition to CAASTRO's armoury of collaborative tools has been a videoconference system that has been installed at each of the six research nodes within Australia. By installing this system, combined with portable laptop versions for 'away' use, our researchers have been able to decrease travel time and costs, increase research output, and foster research relationships that would previously have been difficult.

Examples of typical use of CAASTRO videoconferencing equipment are:

- Weekly management meetings between Perth and Sydney
- Monthly executive meetings involving CAASTRO chief investigators located in Canberra, Melbourne, Perth and Sydney, often joined by representatives from partner organisations such as AAO, CSIRO and NCI.
- Research meetings involving researchers in two or three nodes.
- Regular meetings of researchers with students they co-supervise in other nodes.
- Quarterly Radio Telescope Advisory Committee meetings involving researchers in all six nodes plus the University of Tasmania.

CAASTRO videoconferencing is remarkably successful. Given that, in the era of Skype, videoconferencing is not exactly new, what are the keys to its successful deployment for CAASTRO? They include:

- High quality, high definition video and sound, giving a closer approximation to 'being there'.
- Fast, reliable IP connections, taking the focus away from dropped calls and poor audio-visual, making scientific discussion more transparent.
- Low latency equipment capable of delivering voice and picture in sync, again delivering more of a feeling of physical presence.
- A channel to allow sharing of presentations, which are very common in the astronomy world.

However, in addition to technical capability, which has been available for some time, an important aspect has been a simple user interface, common between nodes. Virtual meeting rooms for casual users as well as pre-booked calls for larger meetings result in a good degree of spur-of-the-moment use, as well as good reliability for scheduled meetings.

National Innovation Priority Case Study

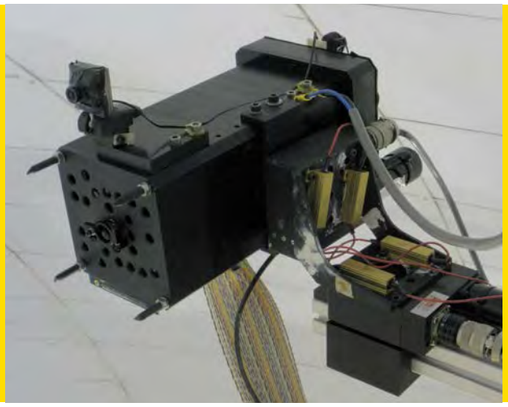
INTERNATIONAL COLLABORATIONS ON RESEARCH

Professor Stuart Wyithe (University of Melbourne)

CAASTRO is partnering with researchers at the Max Planck Institute for Astrophysics (MPA) in Garching, Germany to study the effects of hydrogen absorption on cosmological results from a new class of all-sky survey. The Hobberly-Eberly Telescope Dark Energy Explorer (HETDEX) will measure the positions of 800,000 Ly-alpha emitters to determine baryon-acoustic oscillations, with the goal of ascertaining the contribution of dark energy in the Universe at the highest redshift yet achieved ($z = 3$). Unlike traditional galaxy redshift surveys, the selection of galaxies via their Ly-alpha emission can lead to non-gravitational contributions to clustering, which can mask or mimic the cosmological effects of interest. Unfortunately it is impractical to simulate the effect directly as the cosmological effects are on very large scales, while the radiative transfer effects on the Ly-alpha can be seen only at very small scales.

We are collaborating on a novel hybrid technique, utilising the expertise within CAASTRO in analytic modelling of linear cosmology, combined with Ly-alpha radiative transfer expertise developed at MPA by Dr Benedetta Ciardi and Dr Akila Jeeson-Daniel (now a CAASTRO postdoctoral scientist). Also contributing to this effort is CAASTRO PhD student Brad Greig who is studying non-linear effects in the clustering of Ly-alpha emitters with Max-Planck director Professor Eichiro Komatsu, who leads the HETDEX cosmological analysis.

December 2012 MWA commissioning "busy week" in Perth
Emil Lenc



The Skydice optical instrument
Patrick Tisserand

National Research Priority Case Study

FRONTIER TECHNOLOGIES

Dr Martin Bell (The University of Sydney)

The members of the Murchison Widefield Array (MWA) commissioning team have had a busy year getting to grips with a new instrument. The MWA is a next generation low frequency radio telescope located at the Murchison Radio Observatory in Western Australia. It consists of 128 tiles – which are sensitive to low frequency radio emission – distributed over an area of approximately 10 square kilometres. One unique property of the telescope is the field of view: up to 2,000 degrees^2 can be observed in one pointing. With the ability to survey vast amounts of sky within a relatively unexplored frequency regime, the MWA is expected to be a wide-field flagship resource for CAASTRO.

From September 2012 the commissioning team, led by Dr. Randall Wayth (ICRAR | Curtin University), has been progressively connecting together different 32-tile configurations of the telescope to the test functionality, and producing early science. These configurations have increased in baseline length, from the shortest (at around 100 metres) in early September 2012, to the longest (3 kilometres) in December 2012. By commissioning each configuration separately, the team have gained a detailed understanding of the calibration and imaging techniques needed in each baseline/resolution regime. This staged rollout is a stepping stone to connecting and commissioning the full 128-tile array together in early 2013.

Even during the commissioning phases, phenomenal images have been produced and a smorgasbord of science quality experiments has taken place. The team is anxiously waiting to get their hands on the full array in 2013.

National Innovation Priority Case Study

DEVELOPING A STRONG BASE OF SKILLED RESEARCHERS

Professor Stuart Wyithe (University of Melbourne)

CAASTRO researchers are embracing the use of high performance computing in a range of astrophysical applications. Through our partnership with National Computational Infrastructure (NCI), during 2012 CAASTRO researchers utilised resources totalling 4 million CPU hours, studying phenomena across all 3 CAASTRO themes and all CAASTRO nodes.

Within the Dynamic Theme, CAASTRO Associate Investigator Dr Stuart Sim with PhD student Sharon Rapaport at the Australian National University node performed state-of-the art radiative transfer simulations of thermonuclear and core-collapse explosions in order to try and understand the physics of Type Ia supernovae. Type Ia supernovae were used to measure the cosmic distances that led to the discovery of the accelerating Universe. Also in the Dynamic Theme, CAASTRO Partner Investigator Professor Michael Kramer (Max-Planck Institute for Radioastronomy, Germany) and Chief Investigator Professor Matthew Bailes (Swinburne University of Technology) used the NCI facilities to make a search for highly accelerated binary pulsars. High performance computing is needed to discover the dispersed periodic signals among the large radio data sets that form the basis of pulsar searchers. These searches have led to many fundamental discoveries in compact astrophysical objects including the "Diamond Planet" (see 2011 Annual Report).

In the Dark Theme, CAASTRO researcher Dr Jun Koda (Swinburne University of Technology) is using NCI to make simulations of large scale galaxy distribution for comparison with observed galaxy redshift surveys. The small ripples in the background density that follow from the recombination era are reflected in the distribution of galaxies in the nearby Universe. The size of these ripples provides information on the contribution of dark mass and dark energy to the Universe, but extracting this information requires careful calibration against simulation.

In the Evolving Theme, CAASTRO researcher Dr Edoardo Tescari and PhD student Antonios Katsianis (both University of Melbourne) are studying the interplay between galaxies and intergalactic gas at high redshift by making hydrodynamical simulations of how gas gets into galaxies as they form, how it turns into stars, and the effect that this star formation has on the surrounding gas. These simulations are being compared to observations of galaxy numbers at the highest redshifts observed, and also to the properties of the surrounding gas.

Each of these projects represents state of the art use of high-performance computing in astronomy. These studies are helping entrench the wide spread use of high-performance computing in Australian astronomy, and are expanding the Australian expertise base in this area by recruiting skilled postdoctoral researchers and training a new generation of PhD students.

National Research Priority Case Study

FRONTIER TECHNOLOGIES

Dr Patrick Tisserand (Australian National University)

CAASTRO is partnering with researchers at the LPNHE laboratory in Paris to test and optimise a new system that will reference the calibration of photometric data produced by the SkyMapper telescope, with the aim of achieving an overall photometric accuracy of 0.1%.

To succeed in these two challenges, an optical instrument, called SkyDice, was designed and built by our French colleagues, led by Dr Nicolas Regnault. It was installed in June 2012 on the inside dome of SkyMapper and is now looking downward to illuminate the primary mirror. SkyDice is primarily made of 18 narrow-bandwidth LEDs that cover the entire visible spectrum. Particular attention has been paid to control the quantity of light emitted by each LED in different temperature conditions with a high degree of precision.

The SkyDice system has the real potential to revolutionise the field of astronomy. First, it can replace the traditional photometric system of reference, i.e stars, by a human-made and controlled light system based on LEDs that can be reproduced by any observatory. Second, the daily monitoring of the telescope will give us a comprehensive understanding at all visible wavelengths of the transmission along the optical path: from the variation of reflectivity of the mirrors, the internal reflections between lenses, filters and protective glasses, to any scattering light.

We are finalising the integration of SkyDice into the SkyMapper computing system and expect to start automatic monitoring of the telescope in early 2013.

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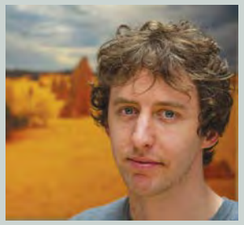
STUDENT LIFE



Andrew Johnson

**CAASTRO PhD STUDENT,
SWINBURNE UNIVERSITY OF TECHNOLOGY**

I am a first year PhD student based at Swinburne University of Technology in Melbourne. I completed my undergraduate degree in Mathematics and Physics at the University of Canterbury in Christchurch, New Zealand. Continuing on at the University of Canterbury I completed honours in Physics and then as I was interested in studying more advanced mathematics, I spent half a year taking honours papers in mathematics.

Shortly after, I moved to Melbourne to start a PhD in cosmology. My supervisors are Chris Blake (Swinburne University of Technology), David Wiltshire (University of Canterbury, New Zealand) and Tamara Davis (University of Queensland).

The broad aim of my PhD is to test through observations non-standard cosmological models, specifically inhomogeneous cosmological models. Embedded within the framework of the standard cosmological model Lambda Cold Dark Matter is the assumption of homogeneity and isotropy. Such assumptions are clearly justified at very large scales but this assumption breaks down when approaching small scales. This breakdown of foundational assumptions may have interesting implications to the observed cosmological expansion.

Currently I am working on constraining the velocity power spectrum using the 6dF peculiar velocity data. The standard cosmological model has strong theoretical predictions for the velocity power spectrum, hence the analysis allows both constraints on the parameters describing the model and also a consistency check of the model.

Samuel Oransaye

**CAASTRO PhD STUDENT,
ICRAR | CURTIN UNIVERSITY**

I am a 1st year PhD student at Curtin University, being supervised by Steven Tingay, Steve Ord, Ramesh Bhat, and Steven Tremblay. I obtained my BSc (Hons) and MSc degrees from the University of Nigeria, Nsukka, in physics and astrophysics, respectively. I later took up another MSc program in space physics at Rhodes University, South Africa, where I did research on space science under the auspices of South African National Space Agency and developed a model for predicting the ionospheric propagation factor for high radio frequencies.

I am currently researching pulsars and rotating radio transients, in line with the CAASTRO's Dynamic Universe theme. My PhD project involves undertaking a sky survey for such objects with the upcoming Murchison Widefield Array (MWA) - a low-frequency precursor to the Square Kilometre Array. The MWA team is currently developing a baseband data capture system for the MWA, which will enable high-time resolution science applications including pulsar astrophysics and exploration of short-duration transients.

Christina Magoulas

**CAASTRO PhD STUDENT,
UNIVERSITY OF MELBOURNE**

I am a graduate of University of Melbourne Physics and recently completed my Ph.D. in November 2012 in collaboration with the Australian Astronomical Observatory. My research involved studying the Fundamental Plane of early-type galaxies - both as an important scaling relation for studying the formation and evolution of galaxies that occupy the Fundamental Plane and as a distance indicator to measure peculiar motions of early-type galaxies in the nearby universe. Using the Fundamental Plane, I measured distances and peculiar velocities for 10,000 of the brightest early-type galaxies in the 6dF Galaxy Survey to form the largest and most homogeneous peculiar velocity sample to date (6dFGSv).

I joined CAASTRO in September 2011 and am currently working on extracting cosmology from the 6dFGS peculiar velocity survey. This project involves providing independent constraints on cosmological parameters defining models of large-scale structure formation, working with Chris Springob (ICRAR | University of Western Australia), Matthew Colless (Australian National University), Heath Jones (Monash University) and Jeremy Mould (Swinburne University of Technology).

Syed Ashraf Uddin

**CAASTRO PhD STUDENT,
SWINBURNE UNIVERSITY OF TECHNOLOGY**

I am a PhD candidate at the Centre for Astrophysics and Supercomputing, Swinburne University of Technology. Prior to that I completed Masters degrees in Physics from University of Kentucky, United States and in Radio Astronomy & Space Science from Onsala Space Observatory, Chalmers University of Technology, Sweden. I carried out my undergraduate study in Mechanical Engineering at Bangladesh University of Engineering & Technology. Understanding the nature of the entire universe has encouraged me towards astronomy and towards cosmology in particular.

My PhD thesis is on supernova cosmology. I am working under the supervision of Jeremy Mould, Chris Lidman and Karl Glazebrook. I am particularly interested in looking at the systematic uncertainties in cosmological parameters that originate from the study of Type Ia supernovae hosted in early and late type galaxies. I will be looking to see if a Hubble diagram constructed with supernova distances and redshifts only from early type galaxies has less systematic error and thereby might improve constraints on cosmology. This may give important insight on the nature of cosmic acceleration.

I am also collaborating with the Dark Energy Survey as part of OzDES. My role is to use the AAOmega spectrograph on the AAT for spectroscopic follow-up of supernova candidates from DECam. This will add an important dataset for my thesis along with SNLS, SDSS, SCP, and other transient surveys.

I have experience working in optical, radio, and infrared astronomy from both ground-based and space-based data. Besides my main research I have enlisted to take part in CAASTRO outreach programs and public talks and writings on astronomy at Swinburne.

Sarah Reeves

CAASTRO PhD STUDENT,
THE UNIVERSITY OF SYDNEY | CSIRO

I am a joint PhD student with the University of Sydney and CSIRO Astronomy and Space Science (CASS), where I work with my three supervisors Elaine Sadler (Sydney), Baerbel Koribalski (CASS) and Tara Murphy (Sydney).

I completed my undergraduate degree, a Bachelor of Science, also at the University of Sydney, in 2009. I always loved Astronomy, but until I did my honours year in Astronomy I never realised that it could be a 'serious' career. After Honours, I took a year off to do some travelling, but returned to start my PhD in 2011.

So far in my PhD I have been conducting a search for HI absorption in a sample of nearby galaxies. HI absorption occurs when a reservoir of HI gas is located along the sightline to a background continuum source, and provides a probe of neutral hydrogen which is essentially independent of distance.

Using observations with the Australia Telescope Compact Array (ATCA), I can simultaneously search for HI absorption and map the HI emission from these galaxies. My aim is to determine how the detection rate of HI absorption varies with distance from the centre of the galaxy. So far I've detected one absorption line, but by comparing the absorption- and emission-line data, I gain much more information about the gas distribution, and how this relates to the absorption-line detection rate. This work forms important preparation for the planned ASKAP-FLASH survey which will use HI absorption to study galaxy evolution at high redshift.

Through CAASTRO I've had the opportunity to meet many leading scientists in my field. I also got to spend 4 weeks in the Netherlands last year, working with collaborators at ASTRON.

2012 CAASTRO Students at the Annual Retreat

2012 CAASTRO Early Career Researchers at the Annual Retreat

2012 NEW CAASTRO STUDENTS

University of Sydney

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

University of Melbourne

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

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

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

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

Australian National University

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

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

Curtin University

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

Swinburne University of Technology

Lina Levin *Dynamic, PhD*
SUPERVISORS Matthew Bailes, Michael Kramer
THESIS TITLE A Search for Radio Pulsars: from Millisecond Pulsars to Magnetars

Ben Barsdell *Dynamic, PhD*
SUPERVISORS Matthew Bailes, Christopher Fluke, David Barnes
THESIS TITLE Advanced Architectures for Astrophysical Supercomputing

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, and 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

CONTINUING CAASTRO STUDENTS

University of Sydney

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

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

University of Melbourne

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

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

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

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

Australian National University

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

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

Sharon Rapoport *Dynamic, PhD*
SUPERVISOR Brian Schmidt
THESIS TITLE Gamma Ray Bursts and Exploding Stars

ICRAR | Curtin University

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

ICRAR | University of Western Australia

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

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 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 six 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:

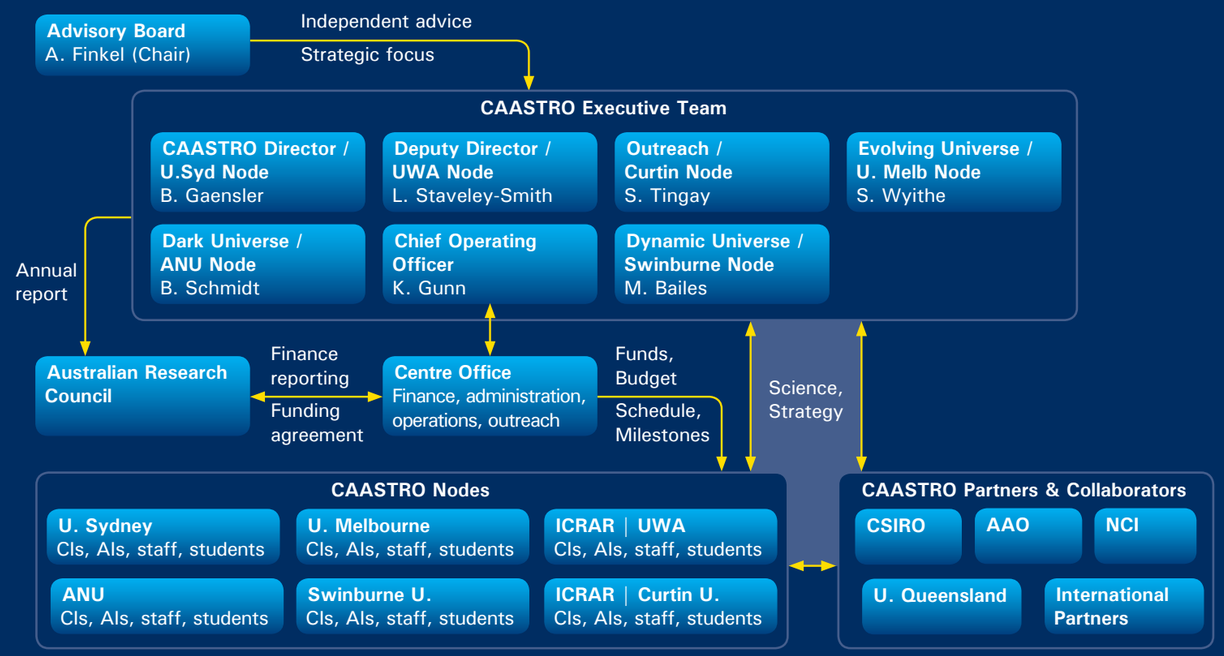
Professor Bryan Gaensler	Research Director
Professor Lister Staveley-Smith	Deputy Director
Ms Kate Gunn	Chief Operating Officer

In 2012, the CAASTRO Executive met 10 times, including face-to-face meetings at the University of Melbourne, University of Sydney, ICRAR and at the Australian National University. During 2012, 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 2012, CAASTRO appointed Theme Scientists for the first time to assist our Theme Leaders. The Theme Scientists serve in this role for a 12 month period, and gain leadership experience and new skills during this time.

CAASTRO is committed to gender equality and participation, and our policies support family friendly and flexible working arrangements. CAASTRO offers all our jobs with a part-time option.

The following diagram shows the CAASTRO Governance structure:



CAASTRO Advisory Board

The CAASTRO Advisory Board met three times in 2012, including a two day meeting held in Sydney 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
Prof Garth Illingworth
Professor of Astronomy & Astrophysics
University of California Santa Cruz

MEMBER
Ms Soula Bennett
Director
Quantum Victoria

MEMBER
Prof Tanya Monro
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Prismatic Sciences

MEMBER
Prof Bryan Gaensler
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MEMBER
Dr Ziggy Switkowski
Chancellor
RMIT University

MEMBER
Prof Martha Haynes
Goldwin Smith Professor of Astronomy
Cornell University

CAASTRO Executive

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

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
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 CAASTRO's talented team continued to flow in 2012, with a number of team members receiving awards and honours for their achievements. Amongst the highlights were:

Brian Schmidt was awarded *The Australian*[1] newspaper's "Australian of the Year", and was elected as a Fellow of the Royal Society.

Tara Murphy was named New South Wales Young Tall Poppy of the Year. Awarded by the Australian Institute of Policy and Science, the award recognises young scientists for their outstanding work in their field as well as actively engaging in outreach with the community.

Working in astroinformatics at The University of Sydney, Tara is leading the VAST project which will use the recently commissioned Australian Square Kilometre Array Pathfinder, while in outreach she is involved with, amongst other things, a new online competition for high school students and the general public, covering a range of science areas.

Steven Tingay was appointed Western Australia's Science Ambassador of the Year.

Steven has played a key role in communicating the significance of radio astronomy and the Square Kilometre Array to the public, to the science community, to industry and to governments, at state, national and international levels. He is a co-instigator of "Ilgarijiri – Things Belonging to the Sky", an art-meets-astronomy project that inspires young Indigenous people to consider careers in science and technology related fields.

Steven creates many opportunities to engage young people, demonstrating that careers in science are diverse, challenging, enjoyable and highly relevant to modern society. This carries over into his undergraduate teaching in astronomy and physics and his supervision of graduate research students.

Kate Gunn was named as one of Australia's 100 Women of Influence by the *Australian Financial Review* and Westpac. This was in recognition of her contribution to the business community and the not-for-profit sector through her work with the National Foundation for Australian Women.

Lister Staveley-Smith won the "Excellence in Postgraduate Supervision" award at the University of Western Australia. The Faculty of Life and Physical Sciences of The University of Western Australia (UWA) in Perth recognises, promotes and rewards excellent teaching and support of teaching. Lister won this award following nomination by his students

Guinevere Kauffmann was elected as a member of the US National Academy of Sciences for her work on the formation and evolution of galaxies.

Paul Hancock, Jean-Pierre Macquart and Randall Wayth were all awarded prestigious Curtin Research Fellowships.

Morag Scrimgeour received the bankmecu Student Scholarship, which was awarded at the annual *Malcolm McIntosh Lecture*, on Wednesday 4 April 2012.

Sean Farrell received the Astronomical Society of Australia's Louise Webster Prize for outstanding early-career research.

Karl Glazebrook won the Thomson Reuters Australian Citation and Innovation Award as the most cited academic in Australia.

Warrick Couch was awarded an honorary doctorate from the Victoria University of Wellington, New Zealand.

1 *The Australian* 26 January 2012

TARA MURPHY WINS NSW TALL POPPY OF THE YEAR AWARD | ***Camille Thomson, Tall Poppy Awards***

BRIAN SCHMIDT WITH THE GOVERNOR GENERAL
Bryan Gaensler

STEVEN TINGAY, WA SCIENCE AMBASSADOR OF THE YEAR
WA Science Awards

KATE GUNN, A WOMAN OF INFLUENCE

Invited Talks 2012

Major Conferences

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

Deep HI surveys (LADUMA + DINGO + APERTIF MDS)
Martin Meyer, Parameterisation of Galaxies in HI 2012, South Africa, January 2012

What can current galaxy formation models tell us about HI in galaxies
Chris Power, Parameterisation of Galaxies in HI 2012, South Africa, January 2012

WALLABY kinematic parameter extraction, Part I
Se-Heon Oh, Parameterisation of Galaxies in HI 2012, South Africa, January 2012

Wide-field HI surveys (WALLABY + WNSHS)
Lister Staveley-Smith, Parameterisation of Galaxies in HI 2012, South Africa, January 2012

Properties of Lyman-alpha galaxies: the interplay between galaxies and intergalactic gas at high redshift
Edoardo Tescari, Trieste 2012 Hydro-Simulation Workshop, Italy, January 2012

WALLABY
Lister Staveley-Smith, Looking at the Distant Universe with the Meerkat Array (LADUMA) Meeting, South Africa, January 2012

Early Universe/EoR
Stuart Wyithe, SKANZ Meeting, 2012, New Zealand, February 2012

Secondary distance indicators
Jeremy Mould, The Hubble Constant: Current and Future Challenges, USA, February 2012

The Accelerating Universe
Brian Schmidt , Fireworks Meeting, UK, April 2012; National Academy of Sciences Meeting, USA, April 2012; Royal Society Kavli Meeting, UK, April 2012; and Transient Meeting, UK, April 2012

Fundamental limits of radio interferometers: calibration and source parameter estimation
Cathryn Trott, Resolving the Sky - Radio Interferometry: Past, Present and Future, UK, April 2012

Commensal transient surveys
Paul Hancock, Exploring the Radio Continuum Universe with SKA Pathfinders, Australia, May 2012

Dark energy with the WiggleZ survey
Chris Blake, Heart of Darkness, France, June 2012

Review of M31 Bulge
Jeremy Mould, Martin Schwarzschild Centennial Meeting, USA, June 2012

Multiwavelength studies of E+A galaxies: the fate of their gas supplies
Warrick Couch, Multiwavelength Surveys: A vintage decade, Australia, June 2012

Studies of transients and variables with the Murchison Widefield Array
Martin Bell, Annual Scientific Meeting of the Astronomical Society of Australia, Australia, July 2012

Numerical challenges for 21-cm data analysis
Daniel Mitchell, Numerical Cosmology, UK, July 2012

IFU studies of rapidly evolving galaxies
Warrick Couch, Galaxy Surveys using Integral Field Spectroscopy, Germany, August 2012

Bias and gender in astronomy
Bryan Gaensler, XXVIII IAU General Assembly, China, August 2012

Magnetic fields in the Milky Way and Magellenic Clouds
Bryan Gaensler, XXVIII IAU General Assembly, China, August 2012

Magnetism in Heaven and Earth
Bryan Gaensler, XXVIII IAU General Assembly, China, August 2012

The multi-wavelength context: the link to radio astronomy
Anne Green, XXVIII IAU General Assembly, China, August 2012

Interstellar scattering
Jean-Pierre Macquart, XXVIII IAU General Assembly, China, August 2012

CAASTRO: A new way of looking at the sky
Bryan Gaensler, Wide-Field Optical Astronomy from Antarctica, Australia, August 2012

SkyMapper transient program
Fang Yuan, Wide-field Optical Astronomy from Antarctica, Australia, August 2012

The SAMI survey
Julia Bryant, Galaxy Surveys using Integral Field Spectroscopy, Germany, September 2012

Spectroscopic dissection of E+A galaxies with Gemini
Warrick Couch, 2012 Australian Gemini & Magellan Science Symposium, Australia, October 2012

Pulsar searching & timing with the SKA
Andrew Jameson, SKA SDP/NVIDIA Meeting, USA, October 2012

Deep HI surveys of the Universe
Lister Staveley-Smith, Frontiers in Radio Astronomy and FAST Early Sciences Symposium 2012, China, November 2012

Semi-analytic models of galaxy formation
Genevieve Kauffmann, Galaxy Surveys using Integral Field Spectroscopy, Germany, November 2012

Varied career paths
Anne Green, Women in Astronomy workshop, Australia, November 2012

A postdoc's look at education and outreach
Greg Madsen, 2012 Bolton Symposium, Australia, December 2012

Galaxy formation modelling predictions for the TAIPAN and WALLABY surveys
Chris Power, The Next Generation of Hemispheric Redshift Surveys and the Prospects for TAIPAN, Australia, December 2012

Other Presentations 2012

Conferences, Workshops, Colloquia, Projects, Collaborations

Pulsars and Gravitational Waves
Ramesh Bhat, Astronomical Society of Victoria, Australia, January 2012

The Accelerating Universe
Brian Schmidt, Pierre et Marie Curie Colloquium, France; Class taught at LPNHE, France; and Colloquium, France, January 2012

High-resolution rotation curves and mass models of little things
Se-Heon Oh, American Astronomical Society Meeting, USA, January 2012

Cosmology from the WiggleZ Dark Energy Survey
Chris Blake, 219th meeting of the American Astronomical Society, January 2012

The Hubble Constant: Current and Future Challenges
Chris Blake, SLAC, USA, February 2012

Modelling Feedback from Super-Massive Black Holes
Chris Power, SAMI workshop 2012, Australia, February 2012

6dF Dark Matter Measurements
Jeremy Mould, Cosmic Flows, Australia, February 2012

Forecasting constrains from peculiar velocity power spectrum
Jun Koda, Cosmic Flows, Australia, February 2012

Cosmology from the WiggleZ Dark Energy Survey
Chris Blake, Cosmic Flows, Australia, February 2012

WALLABY
Lister Staveley-Smith, Cosmic Flows, Australia, February 2012

Tully Fisher Surveys
Jeremy Mould, SAMI Workshop, Australia, February 2012

Millimetre Observations of SNR 1987A
Lister Staveley-Smith, ALMA community workshop, Australia, February 2012

Simulations
Martin Meyer, Parameterisation of Galaxies in HI 2012, South Africa, February 2012

Crab giant pulses at low radio frequencies
Ramesh Bhat, The 2012 Orange Pulsar Meeting, Australia, February 2012

CAASTRO Astronomy Outreach & the Demographics of Social Media
Wiebke Ebeling, Australian Science Communicators - National Conference 2012, Australia, February 2012

Low frequency spectral index & polarisation mapping of Centaurus A & nearby radio galaxies with the MWA
Ben McKinley, Feast-of-Facts, Canberra, March 2012

SN 2011fe - The supernova of a generation
Mike Childress, Feast-of-Facts Canberra, March 2012

The Accelerating Universe
Brian Schmidt, 'Evening with Astronomers', Keck Advancement Director, USA, March 2012

Looking SHARP with Gravitational Lensing
David Lagattuta, Keck Science Workshop, Australia, March 2012

Host Galaxies of Type Ia Supernovae from the Nearby Supernova Factory
Mike Childress, Colloquium RSAA ANU, Australia, March 2012

MWA primary beam model comparisons
Ben McKinley, MWA Analysis Meeting, Australia, April 2012

The Power Spectrum of Redshifted 21cm Fluctuations in Hierarchical Galaxy formation Models
Hansik Kim, Astounding Stories of Super Science, Australia, April 2012

Compact Continuum Source Finding
Paul Hancock, Astounding Stories of Super Science, Australia, April 2012

Reionization and the thermal state of the intergalactic medium
James Bolton, The Epoch of Reionisation – theory, simulations, observations, France, April 2012

The Diamond Planet - With great power comes great responsibility
Wiebke Ebeling, 12th International Public Communication of Science & Technology Conference, Italy, April 2012

Novel observing modes with the MWA
Ben McKinley, MWA Analysis Meeting, Australia, April 2012

Source detection and estimation using interferometric visibilities
Cathryn Trott, SPARCS2 Meeting, Australia, May 2012

Galaxy transformation in the major merger A2744
Warrick Couch, "Clusters as Cosmic Laboratories" meeting, Spain, May 2012

Surveys with the SKA Molonglo Pathfinder (SKAMP)
Anne Green, Multiwavelength Surveys: A Vintage Decade, Australia, June 2012

CAASTRO: A New Way of Looking At The Sky
Bryan Gaensler, Multiwavelength Surveys: A Vintage Decade, Australia, June 2012

Direct Shear Mapping
Catherine de Burgh-Day, Multiwavelength Surveys: A Vintage Decade, Australia, June 2012

Massively multiplexed IFU surveys with SAMI
Scott Croom, Multiwavelength Surveys: A Vintage Decade, Australia, June 2012

Keynote address
Brian Schmidt , Multiwavelength Surveys: A Vintage Decade, Australia, June 2012

The Structure of Reionisation in Hierarchical Galaxy Formation Models
Hansik Kim, Workshop for Korean Young Cosmologists 2012 Conference, Korea, June 2012

Mapping Dark Matter with 6dF
Jeremy Mould, 220th meeting of the American Astronomical Society, USA, June 2012

MWA Transients
Martin Bell, MWA Project Meeting, India, June 2012

Observing the Moon and Centaurus A with the MWA
Ben McKinley, MWA Project Meeting, India, June 2012

SKA Pathfinders
Matthew Bailes, IPTA Workshop, Australia, June 2012

The Big Picture
Warrick Couch, ASA ECR Workshop, Australia, June 2012

MWA observations of the Moon and Centaurus A
Ben McKinley, Harvard-Smithsonian Center for Astrophysics (CfA), USA, June 2012

Calibration of low-frequency radio interferometers
Cathryn Trott, Annual Meeting of the Astronomical Society of Australia, Australia, July 2012

Mining the Optically Variable Sky since 1950
Greg Madsen, Annual Meeting of the Astronomical Society of Australia, Australia, July 2012

BIGHORNS: Broadband Instrument for Global Hydrogen Reionization Signal
Marcin Sokolowski, Annual Meeting of the Astronomical Society of Australia, Australia, July 2012

Surveys for Transients and Variables with the MWA
Martin Bell, Annual Meeting of the Astronomical Society of Australia, Australia, July 2012

Communicating 'A New Way of Looking at the Sky'
Wiebke Ebeling, Annual Meeting of the Astronomical Society of Australia, Australia, July 2012

SAMI - A new multi-object IFS for the Anglo-Australian Telescope
Julia Bryant, SPIE Conference, The Netherlands, July 2012

Square-core bundles for astronomical imaging
Julia Bryant, SPIE Conference, The Netherlands, July 2012

Velocity power spectrum in redshift space
Jun Koda, Summer School on Cosmology, Italy, July 2012

Expectations for new radio telescopes: the HI view
Lister Staveley-Smith, The European Week of Astronomy and Space Science, Italy, July 2012

Temporal evolution of Radio emission from SN 1987A
Lister Staveley-Smith, The European Week of Astronomy and Space Science, Italy, July 2012

Complete ionisation of the neutral gas in high redshift radio galaxies and quasars
Steve Curran, The European Week of Astronomy and Space Science, Italy; University of Glasgow, UK; Royal Observatory Edinburgh, UK; University of St Andrews, UK; University of Sussex, UK, July 2012

Environments & Progenitors of Supernovae
Mike Childress, Melbourne, Swinburne and Monash Universities Talk Series, Australia, July 2012

Complete ionisation of the neutral gas in high redshift radio galaxies and quasars
Steve Curran, XXVIII IAU General Assembly, China, August 2012

CAASTRO: A new way of looking at the sky
Bryan Gaensler, ARC Centre Director's Forum, Australia, August 2012

SkyMapper Transient Program
Fang Yuan, Wide-field Optical Astronomy from Antarctica, Australia, August 2012

Early science from SAMI
James Allen, Galaxy Surveys using Integral Field Spectroscopy", Germany, August 2012

Bridging the Gap Between Stellar Mass and Supermassive Black Holes
Sean Farrell, Half a Century of X-ray Astronomy, Greece, September 2012

How institutions can help? Personal views/experience and best practices
Cathryn Trott, Women in Astronomy, Australia, October 2012

Substructure in SHARP Survey
David Lagattuta, ORELSE Workshop, France, October 2012

Radio faint GRB afterglows
Paul Hancock, Gamma Ray Burst 2012, Spain, October 2012

Bridging the Gap Between Stellar Mass and Supermassive Black Holes
Sean Farrell, X-ray Astronomy: towards the next 50 years, Italy, October 2012

LOFAR RFI statistics and implications for global EoR experiments
André Offringa, The Global Reionisation Signature, Australia, November 2012

FM Radio from the Moon
Ben McKinley, The Global Reionisation Signature, Australia, November 2012

MWA observations of the diffuse polarised background
Emil Lenc, The Global Reionisation Signature, Australia, November 2012

Centaurus A at low frequencies
Ben McKinley, MWA Project Meeting, Australia, November 2012

New Algorithms for EoR Analysis
Cathryn Trott, MWA Project Meeting, Australia, November 2012

Polarisation and the MWA
Emil Lenc, MWA Project Meeting, Australia, November 2012

Transients and the MWA
Martin Bell, MWA Project Meeting, Australia, November 2012

Radio faint GRB afterglows
Paul Hancock, MWA Project Meeting, Australia, November 2012

TAIPAN as a Peculiar Velocity Survey
Chris Springob, The Next Generation of Hemispheric Redshift Surveys and the Prospects for TAIPAN, Sydney, Australia, December 2012

The Rotation Measure of the Universe as a Function of Redshift
Bryan Gaensler, The Next Generation of Hemispheric Redshift Surveys and the Prospects for TAIPAN, Sydney, Australia, December 2012

Reconstruction
Jeremy Mould, The Next Generation of Hemispheric Redshift Surveys and the Prospects for TAIPAN, Sydney, Australia, December 2012

Cosmology from TAIPAN
Chris Blake, The Next Generation of Hemispheric Redshift Surveys and the Prospects for TAIPAN, Sydney, Australia, December 2012

Mining the Optically Variable Sky since 1950
Greg Madsen, 2012 Bolton Symposium, Australia, December 2012

Broad, weak 21cm absorption in an early type galaxy: spectral-line finding and parameterisation for future surveys
James Allison, 2012 Bolton Symposium, Australia, December 2012

Radio faint GRB afterglows
Paul Hancock, 2012 Bolton Symposium, Australia, December 2012

Public Lectures 2012

National Science Awards - Inspirational talk to students, Melbourne, Brian Schmidt, February 2012

Kaczmarczik Lecture Drexel University, Philadelphia, USA, Brian Schmidt, March 2012

Bruce Hall Commencement Address, Canberra, Brian Schmidt, March 2012

Burgmann College Commencement Address, Canberra, Brian Schmidt, March 2012

Sutherland Astronomical Society, "Radio Astronomy: Science with Dishes, Chicken Wire, and Supercomputers", Sydney, Greg Madsen, March 2012

Innovation requires global engagement - In Conversation with Prof Brian Schmidt and Prof Andrew Holmes, Foreign Secretary Australian Academy of Science, Melbourne, Brian Schmidt, March 2012

Launch of the Canberra International Music Festival, Canberra, Brian Schmidt, March 2012

Science Meets Superannuation, Melbourne, Brian Schmidt, March 2012

ANU Annual VC's Lecture Series, Canberra, Brian Schmidt, March 2012

Star Light, Star Bright, Canberra, Opening address followed by panel discussion, Canberra, Brian Schmidt, March 2012

'Evening with Astronomers', Keck Advancement Director, Hawaii, "The Accelerating Universe", USA, Brian Schmidt, March 2012

Keck Advancement Meeting, "The Accelerating Universe", Followed by Guided Wine Tasting, Hawaii, USA, Brian Schmidt, March 2012

Marie Currie Lecture, Canberra, Brian Schmidt, March 2012

Public lecture with Charles F. Bolden, Jr., NASA Administrator Public Lecture/Visit to ANU/RSAA, ACT, Brian Schmidt, April 2012

Malcolm McIntosh Lecture, "The Accelerating Universe", Canberra, Brian Schmidt, April 2012

TEDXSydney, "The Universe in 15 mins", Sydney, Brian Schmidt, May 2012

I'm a Scientist, get me out of here!, Perth, Steven Tingay, May 2012

BrisScience Public Lecture, Brisbane, Bryan Gaensler, May 2012

Australian & New Zealand Association for the Advancement of Science, Melbourne, Bradley Greig, May 2012

Arizona University Commencement, "The Accelerating Universe", USA, Brian Schmidt, May 2012

NICTA Big Picture Series, "The Accelerating Universe", Melbourne, Brian Schmidt, May 2012

Harvard Club of Victoria, "The Accelerating Universe", Melbourne, Brian Schmidt, May 2012

Dean's Lecture in Science and Technology, La Trobe University "The Accelerating Universe", Melbourne Brian Schmidt, May 2012

40th Anniversary Celebratory Lecture, "The Accelerating Universe", Dunmore Lang College, Macquarie University, Sydney, Brian Schmidt, May 2012

Event with Andrew Leigh and Andrew Lamming, Canberra, Brian Schmidt, May 2012

Royal Society of Victoria Public Lecture, Melbourne, Rachel Webster, May 2012

Invited lecture, Melbourne Arts Council Solstice event, Melbourne, Warrick Couch, June 2012

ANU Alumni Trip, Various locations, USA, Brian Schmidt, June 2012

Invited Talk, Square Kilometre Array, Ballarat Observatory, Victoria, Jeremy Mould, June 2012

Talk to University of Sydney Parents Network, Sydney, Bryan Gaensler, July 2012

Nobel Laureate Meeting, Lindau, Germany, Brian Schmidt, July 2012

Public Lecture, University of Melbourne, Melbourne, Jeremy Mould, July 2012

Public Lecture, Swinburne University, Melbourne, Jeremy Mould, July 2012

Public Talk, Astronomical Society of Western Australia, Perth, Steven Tingay, July 2012

Induction into the Royal Society, London, UK, Brian Schmidt, July 2012

CHAST Public Lecture, Sydney, Brian Schmidt, July 2012

Allison-Levick Lecture, Sydney, Brian Schmidt, July 2012

Public Lecture, University of New South Wales, Sydney, Brian Schmidt, July 2012

Royal Society, Bowral, Brian Schmidt, July 2012

Australian Academy of Science Open Day, Canberra, Brian Schmidt, July 2012

Australian American Association Canberra Forum, Canberra, Brian Schmidt, July 2012

Nuclei in the Cosmos, Cairns, Brian Schmidt, August 2012

Sleek Geeks, Sydney, Brian Schmidt, August 2012

National Science Week Public Lecture, Albury-Wodonga, Brian Schmidt, August 2012

Mount Burnett Observatory (National Science Week), Melbourne, Warrick Couch, August 2012

Mount Burnett Observatory (National Science Week), Melbourne, David Lagattuta, August 2012

Mount Burnett Observatory (National Science Week), Melbourne, Stuart Wyithe, August 2012

Mount Burnett Observatory (National Science Week), Melbourne, Stephen Ord, August 2012

Sandwich Science Session, WA Museum, Geraldton, Randall Wayth, August 2012

National Science Week Energy and Innovation Expo, Geraldton, Randall Wayth, August 2012

Is Space the Final Frontier?, Canberra, Brian Schmidt, August 2012

IAU Forum, Beijing, China, Brian Schmidt, August 2012

Public Lecture, Swinburne University, Melbourne, Chris Blake, August 2012

"Nerd Nite", Sydney, Bryan Gaensler, September 2012

Astronomical Society of Victoria, Melbourne Jeremy Mould, September 2012

Public lecture, Perth, Bryan Gaensler, September 2012

Public Lecture, University of Western Australia, Perth, Brian Schmidt, September 2012

National Press Club Address, Canberra, Brian Schmidt, September 2012

Speaking at Manning Clark House, Canberra, Brian Schmidt, September 2012

AOC-G Meeting, Santiago, Chile, Brian Schmidt, October 2012

ESO 50th Birthday Celebrations, Munich, Germany, Brian Schmidt, October 2012

Investigator Lecture, Flinders University, Adelaide, Brian Schmidt, October 2012

RiAUS 'Science Inspiration' lecture, Adelaide, Brian Schmidt, October 2012

Astronomical Society of NSW, Sydney, James Allison, November 2012

Several talks about Galaxy Evolution and Astrophotonics to visiting American Group at the Eclipse in Cairns, Julia Bryant, November 2012

Institute for Physics and Mathematics for the Universe, Tokyo, Japan, Brian Schmidt, November 2012

Australian Ambassador Lecture, Washington DC, USA, Bryan Gaensler, November 2012

Keynote address to the Society of University Lawyers Annual Conference, Sydney, Bryan Gaensler, November 2012

Astronomy & Eclipse Presentation, Cairns, Brian Schmidt, November 2012

"How everything came from nothing", York, UK, Carlos Frenk, November 2012

Macarthur Astronomy Forum, Sydney, Emil Lenc, November 2012

AIP 20th National Congress, Sydney, Brian Schmidt, December 2012

Public Lecture, University of Amsterdam, The Netherlands, Brian Schmidt, December 2012

TEDxPerth - Science, Art, Reconciliation, Perth, Steven Tingay, December 2012

Other Outreach Events by CAASTRO Members 2012

40 Radio, TV and Interviews

44 Education and Training Sessions

19 School Talks

44 Science Awareness, Talks and Activity

Roger Davies

Chryssa Kouveliotou

International Visitors to CAASTRO in 2012

Rennan Barkana
Tel Aviv University, Israel

Brent Carlsson
Dominion Radio Astrophysical Observatory, National Research Council, Canada

Tzu-Ching Chang
Academia Sinica Institute of Astronomy and Astrophysics, Taiwan

Abhirup Datta
University of Colorado -Boulder, USA

Roger Davies
University of Oxford, UK

Laurent Le Guillou
Laboratoire de Physique Nucléaire et de Hautes Énergies, France

Nicholas Kaiser
Institute for Astronomy, University of Hawaii, USA

Lars Koens
University of Edinburgh, UK

Chryssa Kouveliotou
NASA Marshall Space Flight Center, USA

Shri Kulkarni
California Institute of Technology, USA

Juliana Kwan
Argonne National Laboratory, USA

Kiyoshi Masui
Canadian Institute for Theoretical Astrophysics, Canada

Peter Michelson
Stanford University, USA

Ue-Li Pen
Canadian Institute for Theoretical Astrophysics, Canada

Nicolas Regnault
Laboratoire de Physique Nucléaire et de Hautes Énergies, France

Philippe Repain
Laboratoire de Physique Nucléaire et de Hautes Énergies, France

Pier-Francesco Rocci
Laboratoire de Physique Nucléaire et de Hautes Énergies, France

Lakshmi Saripalli
Raman Research Institute, India

Kyan Schahmaneche
Laboratoire de Physique Nucléaire et de Hautes Énergies, France

Fergus Simpson
University of Edinburgh, UK

Ravi Subrahmanyan
Raman Research Institute, India

Nithya Thyagarajan
Raman Research Institute, India

Bernard Whiting
University of Florida, USA

Laura Wolz
University College London, UK

Visits to overseas laboratories and facilities in 2012

James Allen
Institute of Astronomy, Cambridge
UK

James Allen
Max-Planck-Institut für Astronomie, Heidelberg
Germany

Matthew Bailes
Square Kilometre Array South Africa
South Africa

Matthew Bailes
CASPER, University of California Berkeley
USA

Matthew Bailes
IAC
China

Martin Bell
Raman Research Institute
India

Chris Blake
Stanford Linear Accelerator Center, Berkeley, Stanford
USA

Chris Blake
University College London
UK

Chris Blake
University of Edinburgh
UK

Frank Briggs
Raman Research Institute
India

Loren Bruns Jr
Magellan Baade Telescope, Las Campanas Observatory
Chile

Julia Bryant
Institut d'Astrophysique Spatiale, Paris
France

Julia Bryant
Meudon Institutes, Paris
France

Julia Bryant
Max Planck Institute for Astrophysics, Munich
Germany

Julia Bryant
Max-Planck-Institut für Extraterrestrische Physik
Germany

Julia Bryant
ESO, Germany
Germany

Julia Bryant
Fraunhofer-Institut für Angewandte Polymerforschung(IAP)/ InnoFSPEC, Potsdam
Germany

Julia Bryant
ASTRON
The Netherlands

Mike Childress
Max Planck Institute for Astrophysics, Garching
Germany

Warrick Couch
Fraunhofer-Institut für Angewandte Polymerforschung(IAP)/ InnoFSPEC, Potsdam
Germany

Wiebke Ebeling
Max Planck Institute for Radio Astronomy, Bonn
Germany

Wiebke Ebeling
Max Planck Institute for Astrophysics, Munich
Germany

Sean Farrell
Anton Pannekoek Institute, University of Amsterdam
The Netherlands

Sean Farrell
Brera Observatory, Merate
Italy

Bryan Gaensler
Raman Research Institute
India

Bryan Gaensler
National Astronomical Observatory of China, Beijing
China

Bryan Gaensler
University of Kentucky, Lexington
USA

Bryan Gaensler
Institute for Astronomy, University of Hawaii, Honolulu
USA

Bradley Greig
University of Texas, Austin
USA

Bradley Greig
Kavli Institute for the Physics and Mathematics of the Universe (IPMU), University of Tokyo
Japan

Eyal Kazin
International Centre for Theoretical Physics, Trieste
Switzerland/Italy

Jun Koda
International Centre for Theoretical Physics, Trieste
Switzerland/Italy

Jun Koda
Yukawa Institute for Theoretical Physics, Kyoto University
Japan

David Lagattuta
W. M. Keck Telescope, Hawaii
USA

David Lagattuta
University of California, San Diego
USA

Laboratoire d'Astrophysique de Marseille (LAM)/L'Observatoire Astronomique Marseille-Provence (OAMP)
France

David Lagattuta
W. M. Keck Telescope, Hawaii
USA

Emil Lenc
Raman Research Institute
India

Ben McKinley
National Radio Astronomy Observatory (NRAO)
USA

Ben McKinley
Raman Research Institute
India

Daniel Mitchell
Raman Research Institute
India

Jeremy Mould
Stanford University
USA

Jeremy Mould
University of Tokyo
Japan

Jeremy Mould
Princeton University
USA

Jeremy Mould
Dominion Astrophysical Observatory,
Canada

Jeremy Mould
IAC
China

Emily Petroff
IAC
China

Pietro Procopio
Raman Research Institute
India

Sarah Reeves
ASTRON
The Netherlands

Emma Ryan-Weber
W. M. Keck Telescope, Hawaii
USA

Brian Schmidt
Pierre et Marie Curie University, Paris
France

Brian Schmidt
École Normale Supérieure, Paris
France

Brian Schmidt
LPNHE, Paris
France

Brian Schmidt
Norte Dame, Carnegie Institute, Drexel University
USA

Brian Schmidt
Carnegie Institution of Science, Washington DC
USA

Brian Schmidt
Drexel University, Philadelphia
USA

Brian Schmidt
University of Notre Dame
USA

Brian Schmidt
The Royal Society
London

Brian Schmidt
Paris Observatory
France

Lister Staveley-Smith
University of Cape Town
South Africa

Lister Staveley-Smith
National Astronomical Observatories of China
China

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

Cath Trott
University of Manchester & Jodrell Bank Observatory
UK

Rachel Webster
Raman Research Institute
India

Stuart Wyithe
La Scuola Normale Superiore, Pisa
Italy

WORKSHOPS

CAASTRO Workshop: Wide Field Optical Astronomy in Antartica
Michael Ashley

SAMI Workshop, Large Surveys in the Multi-IFS Era,

One of the CAASTRO Research Projects in the Evolving Theme is the Sydney-AAO Multi-object IFS (SAMI) Project, a collaboration with the Australian Astronomical Observatory. The CAASTRO project is being led by Associate Professor Scott Croom (The University of Sydney). SAMI is a multi-IFS instrument based on innovative lightly-fused fibre bundles called hexabundles.

The SAMI workshop, co-sponsored by CAASTRO, took place at CSIRO, in Marsfield over 9-10 February 2012. SAMI targeted the workshop at astronomers around Australia and interested parties doing similar research. International speakers spoke mainly in relation to projects rather than specifically about SAMI, putting SAMI into international context.

The essence of the workshop was to bring interested astronomers together to develop the scientific case for large surveys with the SAMI instrument and start the process of building a larger collaboration to carry out this survey.

Cosmic Flow in the Rainforest Workshop

The CAASTRO-supported Cosmic Flow workshop was held over three days in late February 2012 at O'Reilly's Rainforest Retreat in the Gold Coast hinterland. Organised by Associate Professor Tamara Davies (University of Queensland), a group of 35 researchers from around the world gathered to discuss how we can use motions of galaxies to learn about cosmology.

The emphasis of the meeting was on discussion, rather than talks, with a view to identifying key areas of future research and building collaborations. So each day, after a series of brief introduction talks designed to spark discussion, participants separated into break-out groups, brainstormed, and then regathered to compare notes.

The primary focuses were two of the ways we can measure peculiar velocities, chosen because we have active surveys here in Australia that can potentially lead the way in these fields. The first is detecting peculiar velocities statistically through galaxy redshift surveys, and the second is directly detecting peculiar velocities from surveys that can supply distances as well as redshifts. The workshop had representatives from many of the important survey teams worldwide, including 2MRS, 2MTF, 6dFGS, BigBOSS, BOSS, CANDELS, COSMOS, DES, EMU, FASTsound, GAMA, MWA, Pan-STARRS, SNLS, SDSS, SkyMapper, SNLS, TAIPAN, WALLABY and WiggleZ.

The primary questions to answer were two related aspects of motion in the Universe. First, what are the underlying laws of physics that govern that motion? What can we learn about gravity, dark matter and dark energy by measuring that motion? And second, how big are the bulk flows in the universe? Can they be caused by known large scale structures? Are they too large to be explained by the standard cosmological model?

Day One saw David Schlegel (Lawrence Berkeley Laboratory) and Ravi Sheth (University of Pennsylvania / ICTP) lead the discussion on recent and upcoming Large Scale Structure results, concentrating on Baryon Acoustic Oscillations and Redshift-Space distortions. Recent WiggleZ and 6dFGS results were shown to be a great success, with the first high redshift measurements of the growth of structure and intriguing results, not only on the standard cosmological parameters, but also on the possibility of extra neutrino species. The BOSS survey results are being eagerly anticipated, with 50% of the survey now complete and a 2% measure of the equation of state of dark energy expected to be announced by April 2013.

Day Two saw Nick Kaiser (Institute for Astronomy, University of Hawaii) and Mike Hudson (University of Waterloo) lead the discussion on results from recent and upcoming peculiar velocity surveys. There was discussion about larger-than-expected bulk flows, and inconsistencies in bulk flow measurements between surveys. This latter seems to have been resolved to a great extent recently with better analysis techniques, yet tantalisingly large bulk flows remain in the data. Is this a hint of non-standard physics, or non-standard initial conditions?

Day Three saw Nikhil Padmanabhan (Yale University) and Greg Poole (Swinburne University of Technology) lead the discussion on future directions. The clearest need identified was the ability to make theoretical predictions that can be compared to the observational data continuing to come in.

Wide-field Optical Astronomy from Antarctica: a Chinese-Australian Workshop

In January 2012 China installed the first of three 0.5 metre wide-field (1.5 x 2.9 degree) optical imaging telescopes, AST3-1, at the highest point of the Antarctic plateau.

Australia is currently involved in Dome A activities through The University of New South Wales's PLATO-A, which will be the primary support platform for AST3, and through equipment to characterise the infrared background and cloud cover at Dome A.

Australian Astronomy Limited, UNSW and CAASTRO held a 1-day workshop on 13th August 2012 at CAASTRO in Sydney for Australian astronomers to meet with Chinese astronomers involved in the project at Dome A. The objective was to define a plan for Australian contribution to the commencement of significant scientific output from this project.

Around fifty Australian astronomers attended and engaged with invited Chinese astronomers Ji Yang (Purple Mountain Observatory), Lifan Wang (Purple Mountain Observatory/Texas A&M University) and Jilin Zhou (Nanjing University).

The workshop participants successfully identified key science areas for collaboration between Chinese and Australian astronomers using AST3 data and potential complementary instruments and resources in Australia. These areas were:

- Supernova physics, including the detection of prompt emission and the spectroscopic and/or photometric follow-up using Australian telescopes;
- The discovery and characterisation of solar system objects, and exoplanets and their parent stars including detection through transit and lensing observations, and spectroscopic and/or photometric follow-up using Australian telescopes;
- Stellar structure and evolution, including high precision photometry of variable stars and further spectroscopic and/or photometric follow-up using Australian telescopes;
- The physics of the dynamic extragalactic Universe, including coordinated synoptic surveys between AST3/CSTAR and appropriate complementary Australian facilities.

Science Pathways: Getting Science on the National Agenda

Dr Greg Madsen and Dr James Allison, both from The University of Sydney, attended the "Science Pathways: Getting Science on the National Agenda" meeting on 24th-25th September in Canberra. The inaugural meeting of the Australian Early to Mid Career Research Forum was hosted by the Australian Academy of Science at the Shine Dome in Canberra, and co-sponsored by CAASTRO. However this was not your ordinary kind of academic science conference. Its purpose was to engage the Academy with Early and Mid-Career Researchers (EMCRs), from multiple disciplines and institutions around Australia, to exchange views about the challenges they face, and to propose some possible solutions.

The event was a great success with 137 delegates in attendance, consisting mostly of early-mid career researchers (115 PhD students, postdoctoral fellows and junior group leaders), but also Fellows of the Academy, as well as government and industry representatives.

Early Career Researcher Mentoring Workshop

The inaugural Australian astronomy Early Career Researcher mentoring workshop was held in late May 2012 at Shoal Bay, New South Wales. CAASTRO was a co-sponsor, and six of the ten speakers were from CAASTRO, as were many of the attendees. This was an insightful and rewarding meeting, which inspired everyone involved to plan their careers and to strive for work-life balance.

Women in Astronomy Workshop, Swinburne University
Sarah Maddison

The EoR Global Signal Workshop

The CAASTRO workshop on the Epoch of Reionisation (EoR) Global Signal was held at CAASTRO's headquarters in Sydney over 19-21 November 2012. The workshop was attended by approximately 40 local and international researchers including 4 remote participants. The workshop was initiated by CAASTRO Associate Investigator Randall Wayth to bring together, for the first time, the teams and individuals interested in the Global Signal.

The workshop was attended by representatives from all of the experiments currently in progress as well as two of the prominent theorists in the field, and was well attended by CAASTRO members. Attendees included international groups from the Netherlands, India and the United States. Over the 3 days there were many presentations and long discussion sessions aimed at sharing the lessons learned and current state of the art in experiment design and data analysis.

Women in Astronomy Workshop 2012

The second ASA Women in Astronomy workshop was held over 10-11 October 2012 at Swinburne University. The meeting was attended by more than 100 people, including over 30 people streaming online. CAASTRO was a co-sponsor of this event, and Anne Green, Cathryn Trott and Kate Gunn presented at the workshop.

This 2-day workshop focused on how unconscious biases in our professional and personal lives affect women's leadership and participation in the workplace. Over the two days there were both presentations as well as workshop sessions, which covered some of the issues and obstacles that women face during their astronomy careers, and strategies that both women and men can use in overcoming them. Guest speakers included Mary Crooks, Executive Director of the Victorian Women's Trust and workshops were led by Suzanne Mercier and Kate Higgs.

The Workshop Goals were to:

1. Raise awareness of general issues that impact on the decision of women to continue in a research focused career.
2. Illustrate the validity of the many career paths for astronomers.
3. Highlight how institutions can help women succeed in our field.
4. Recognise and combat unconscious biases.

GPU Training Workshop

This workshop, held over 8-9 October 2012 in Perth, introduced the concept of GPU programming and discussed how it can be used. The workshop was led by Shin Kee Chung at the ICRAR | University of Western Australia node.

There was a broad range of delegates from across research and industry. Chris Harris, a GPU expert, gave a good introduction to the subject and a summary of the Fornax GPU cluster. A short tutorial session followed where attendees went through exercises designed to familiarise themselves with the Fornax programming environment.

Shin Kee Chung introduced GPU programming before attendees worked on exercises designed to introduce them to basic programming with GPU. Day two included a lecture on the advanced topic of code optimisation in GPU programming. Jay Banyer gave the closing presentation detailing his attempt in applying GPU acceleration with some astronomy algorithms.

All attendees appreciated the balance between theory and practice taken by the workshop and found the tutorial exercises invaluable as they learnt to write and test code.

(Top) Ken McNamara, Department of Earth Sciences, University of Cambridge provides a short lecture at the Pinnacles, WA

(Other photos) Delegates enjoyed the Annual Retreat in Cervantes, WA

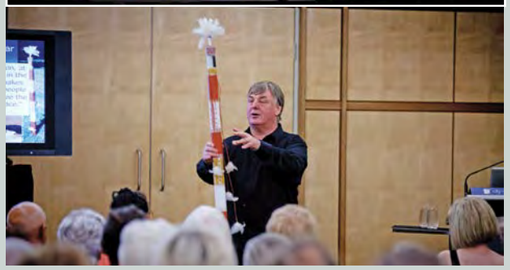
CAASTRO Annual Retreat

The second CAASTRO Annual Retreat was held in Cervantes, Western Australia over 25-27 November 2012. The Retreat was attended by 67 people, and there were over 30 science presentations. Many attendees commented that they especially enjoyed the Theme and Project break-out sessions. Presentations were grouped into our three Research Themes.

CAASTRO was lucky to have Professor Ken McNamara from the Department of Earth Sciences at the University of Cambridge join us to provide a short lecture about the stromatolites at Lake Thetis, and also about the history of the Pinnacles. Most delegates got up early in the morning on either Monday or Tuesday morning to tour the Pinnacles with Ken, and were rewarded with its beauty.

Enthusiastic scientists were also keen to explore the outdoors, with 14 people playing beach volleyball and Frisbee (with rules) on Tuesday morning. Lawn bowls was also popular as a pre-dinner activity on Monday evening. It was good to see that networking continues beyond science collaboration.

EVENTS



NASA Visit

On 4 April 2012, CAASTRO co-hosted a visit to Sydney by NASA Administrator Charles F. Bolden Jr. Administrator Bolden gave an informative talk to a packed audience of over 400 people on NASA's future plans for research and exploration. The event was co-hosted by CAASTRO, the University of Sydney's US Studies Centre and the US Consulate.

Bolden's presentation discussed the next chapter in America's extraordinary story of space exploration and included a Question and Answer Session chaired by Bryan Gaensler with students, academics and the general public.

(Left column) CAASTRO co-hosted the visit by NASA Administrator Charles F. Bolden, Jr.
US Studies Centre, University of Sydney

(Right column) CAASTRO partnered with Musica Viva and (bottom right) Ray Norris spoke prior to one of the Sydney concerts

CAASTRO brings astronomy and music together

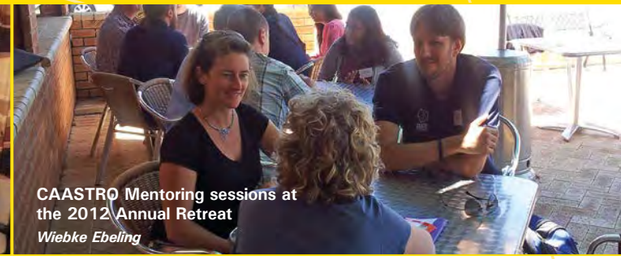
Throughout March 2012, CAASTRO partnered with Musica Viva Australia as the astronomy sponsor of the Canadian music ensemble Tafelmusik. Before ten concerts in six capital cities, CAASTRO astronomers informed and entertained the audience with talks on Galileo, Kepler and the connection between astronomy and music. We thank those who participated for their excellent and stimulating presentations.

CAASTRO's national network of astronomers were a natural fit to Tafelmusik and Musica Viva's series of concerts. In Sydney, Bryan Gaensler presented on the unexpected sounds of deep space, including the loudest and deepest notes in the Universe, and on another night Ray Norris spoke on the connection between Indigenous Astronomy and Galileo.

The musical program was devised in 2009 by Tafelmusik, based in Toronto, to celebrate the International Year of Astronomy, which marked the 400th anniversary of the first recorded astronomical observations with a telescope by Galileo Galilei.

EDUCATION & OUTREACH

Warrick Couch presented at Mt Burnett Observatory during National Science Week
James Murray



CAASTRO Mentoring sessions at the 2012 Annual Retreat
Wiebke Ebeling

In CAASTRO, we take seriously the training and mentoring of the next generation of world-class research scientists. To this end, we not only distribute relevant information on training and employment opportunities to our members, we also provide support in various ways:

Workshops

In 2012, CAASTRO co-sponsored two workshops in conjunction with The Astronomical Society of Australia: 'Early Career Researcher Mentoring' at Shoal Bay (31 May - 1 June) and 'Women in Astronomy' in Melbourne (10 - 11 October).

We also supported the 'Early / Mid Career Researcher Forum' of the Australian Academy of Science at Shine Dome (24 - 25 September) and the 'Nuclei in the Cosmos' School for postgraduate students at Mount Stromlo Observatory (30 July - 3 August), both in Canberra.

Professional Development Day

Every year following the CAASTRO Annual Retreat, the CAASTRO Education & Outreach team organise a Professional Development Day. In 2012, the Science Communication group of the University of Western Australia, under the leadership of Professor Nancy Longnecker, provided training in producing astrophysics-themed video material for the general public. During the day, participants started developing their own video projects that will be continued and completed under the guidance of UWA Science Communication and CAASTRO Education & Outreach.

Career Advice Videos

In the past year, we have produced 11 short videos featuring our Chief Investigators and national and international Partner Investigators for the CAASTRO YouTube channel. These videos are aimed at providing career advice to young people who might not have considered science or astronomy as an employment option or who are looking for guidance regarding the benefits of science education. The career advice video featuring Brian Schmidt has so far proven the most popular with more than 600 views in 2012 alone. Two such videos are also available in German (thanks to CAASTRO Partner Investigators Michael Kramer and Ue-Li Pen), and three others will be released soon with captions in German, Italian and Polish.

CAASTRO Mentoring Program

The CAASTRO Mentoring program was launched in August 2012, and every member of CAASTRO is either a mentor, a mentee or both.

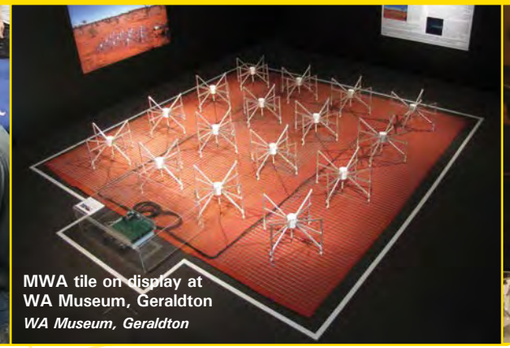
A mentoring relationship is usually where one wiser and more experienced person assists another person to grow and learn. It is not a new management technique: ever since humans have lived in social groups, we have learned our norms, values and behaviours by the example and coaching of others.

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, and 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.

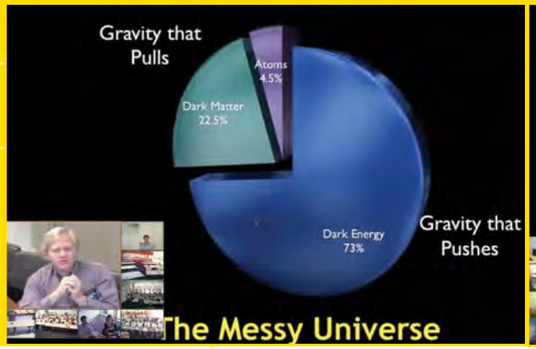
CAASTRO members are encouraged to make use of this valuable network to seek informal communication with their mentor/mentee and to gain new perspectives on their careers. At the 2012 Annual Retreat, there was a designated mentoring session to allow for face-to-face discussions.

CAASTRO participated in Astrofest, WA. Steven Tremblay enjoyed talking to children about astronomy
Ruth Jefferies

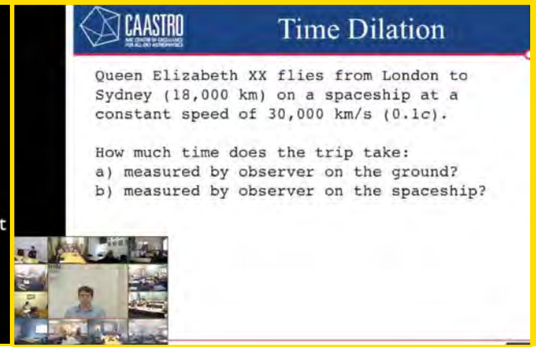


MWA tile on display at WA Museum, Geraldton
WA Museum, Geraldton

Ramesh Bhat at the Science Cafe
Wiebke Ebeling



Nobel Laureate, Brian Schmidt, participated in CAASTRO in the Classroom
Greg Madsen



Greg Madsen presented on Time Dilation
Greg Madsen

Public Outreach & School Engagement

CAASTRO has rolled out a number of programs that are aimed at communicating our research to the interested public across the country.

Astrofest, an evening event in Perth for amateur astronomers and families alike, was held in late March and attracted well over 3,000 visitors. CAASTRO was represented by a number of staff members from our ICRAR-Curtin and ICRAR-UWA nodes.

Fuelled by the site decision for the Square Kilometre Array (SKA) radio telescope, we received numerous requests to set up antenna tile exhibitions based on the Murchison Widefield Array (MWA). Since this low-frequency SKA precursor instrument is too remote for people to visit, the MWA tiles provide a valuable hands-on science engagement activity in radio astronomy, engineering and software development. In 2012, we installed full-size tiles at Wooleen Homestead in the Murchison Shire (permanent display) and at the Western Australian Museum in Geraldton (on display in August and September; over 7000 visitors).

We also organised the display of reduced-size MWA tiles at the official launch of National Science Week at Scitech in Perth (August) and at the 'Big Data' exhibition in the New Zealand National Library in Wellington (November 2012 through to June 2013). As part of National Science Week, MWA Commissioning Scientist and CAASTRO Associate Investigator Dr Randall Wayth participated in a 'Sandwich Science' session at the WA Museum in Geraldton, where he also visited school groups, and presented at the Energy and Innovation Expo.

National Science Week lent itself to a range of other outreach activities across the country. In collaboration with staff at Siding Spring Observatory in New South Wales, we offered a full-day 'Telescope Tour' for teachers and students of Dubbo Senior College to be guided and talked through the exciting science and technology in their backyard. As a contribution from our two Melbourne nodes, we ran a public lecture series at Mount Burnett Observatory in the Dandenong Ranges that was attended by approximately 170 people. In Perth, CAASTRO members from the ICRAR-Curtin node participated in 'Science Café', a speed-networking event for high school students from Western Australia to talk to scientists about their careers.

In CAASTRO, we are extremely fortunate to work in a field that arouses great public curiosity. Our dedicated members frequently make time to share their passion for astronomy and science by visiting schools and amateur astronomy societies, by giving interviews on radio and for newspapers and by presenting at events such as TEDx (Professor Brian Schmidt in May and September 2012 and Professor Steven Tingay in December 2012).

We are also committed to inspiring the next generation of scientists, communicating the challenges and rewards of operating the newest and largest telescopes, and to showcasing the unprecedented flood of astronomical data from these instruments. CAASTRO therefore supports three school engagement programs:

- 'CAASTRO in the Classroom' (see next page) is run by our Sydney node and uses video conferencing technology to connect our researchers across the country to High School students (years 7-12) in New South Wales schools.
- 'Maths & Science EXPOsed' is a bi-annual event held at the University of Western Sydney where students have the chance to obtain information on the diverse career opportunities, chat to exhibitors from all walks of life and to get hands-on experience in various scientific disciplines.
- 'Telescopes in Schools' (see p58) is an award-winning astronomy outreach program based at the University of Melbourne, aimed at providing schools in metropolitan and regional Victoria with a telescope kit and training, including observing nights and exercises.

CAASTRO IN THE CLASSROOM

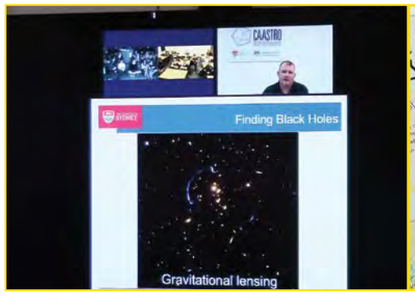
In 2012, our exciting outreach program "CAASTRO in the Classroom" continued to engage Australian school students with astronomers, research scientists and PhD students. CAASTRO in the Classroom links the CAASTRO Videoconferencing infrastructure with the videoconferencing provided by the Interactive Classroom Project within the Connected Classroom Initiative of the NSW State Government, which places video conferencing facilities in every school. The project gets students interested in studying science, allowing them to ask questions about all aspects of space and the Universe, and to find out what day-to-day life is like for a real scientist. We thus aim to help promote science to students who may not have initially considered tertiary education, to show students that science can be exciting and dynamic, and to assist teachers in explaining the more challenging and complex parts of the curriculum.

The program has now grown into a collaborative effort driven by CAASTRO, with support from the NSW Office of Science and Medical Research and the NSW Department of Education and Communities. There have now been more than 1,000 students attend CAASTRO in the Classroom sessions, with speakers ranging from fledgling astronomy students to Nobel Laureates. Teaching staff in the schools have overwhelmingly provided positive feedback, and the current program is liaising closely with these staff to help in catering future talks and projects towards the needs of the modern curriculum.

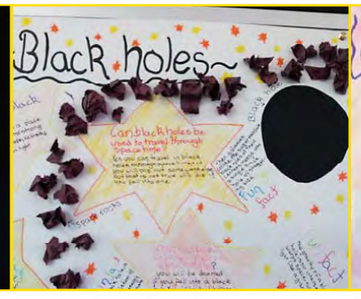
The program will continue to be aimed at years 7-12 in schools across NSW (although younger students have attended). There are currently hopes for an expansion of the project to closely support the national curriculum - with the development of support materials for teachers, and training in how to best explain astronomy concepts to a non-academic audience.

The images below illustrate a session led by Dr Sean Farrell from The University of Sydney, and also examples of the output following the presentation, facilitated by the teacher of Year 6 at Colo Vale Public School (Southern Highlands of NSW).

If they were not already passionate about astronomy, then the project hopes it will continue to encourage future students to aim their sights high - both at night when staring at the stars, and also in the day when choosing their future career path. One thing is for sure: astronomy is amazingly well-placed as an activity that should be accessible to everyone!



Sean Farrell presenting at CAASTRO in the Classroom
Greg Madsen



Colo Vale Public School
Colo Vale PS

Colo Vale Public School
Colo Vale PS

Bright students glimpsing at the Sun
Pascoe Vale Girls College

PUTTING STARS IN THEIR EYES

In 2011 the Telescopes in Schools Pilot Program was launched with the aim of getting students interested in studying science, especially those who wouldn't ordinarily consider tertiary education. The idea was to establish a relationship between school communities and tertiary academics, to let the students see and do real science and to provide complete ongoing support to teaching staff from participating schools.

A partnership was developed between the University of Melbourne, Museum Victoria, Quantum Victoria and CAASTRO, joined with schools selected for their enthusiastic and committed teachers. The University of Melbourne has supported the program through funding for a project coordinator and a bequest to purchase the telescopes. Museum Victoria, Quantum Victoria, the University of Melbourne Astrophysics Group and CAASTRO have supported the teacher professional development program and have provided students and postdocs to support the observing sessions. Finally, the teaching staff in the schools are the lynchpin of the program locally, giving their valuable time and enthusiasm to the program.

The program has developed differently in each school, depending on local interest and activities. 2012 was an excellent year to have telescopes in schools with the transit of Venus and a partial solar eclipse in Melbourne. The participating schools were able to engage their students in a new way for each of these events, and the impact has been immediate. One school has reported that due to their telescope, all their year 11 physics students are continuing to year 12, and their intake into year 11 has doubled. Apart from a range of local newspaper articles and TV cameos, the project has been recognised by a University of Melbourne VC's award for outreach.

The next stage of the program will be to develop a sustainable base for the modest funding requirements, and to develop the photographic and investigative skills of the students, providing an enriching learning experience. Yet, it is always the teachers left saying, 'what else can we look at?', 'just one more thing?' or 'is it that time already?' If they hadn't already had a love for astronomy, they do now and their students are riding along on the enthusiasm and are voting with their feet. The schools eager to take on the program are supporting this endeavour more and more as they see the impact the Telescopes in Schools is having.

Paul Hancock shows students how to use a telescope at "Maths & Science Exposed"
Greg Madsen

Emil Lenc at the Macarthur Astronomy Forum
Roger Powell

CAASTRO's top retweets in 2012
Wiebke Ebeling

CAASTRO & THE MEDIA

Building on the major redesign of the CAASTRO website in late 2011, we have taken great care to provide our visitors with timely and relevant information and resources. We recorded a total of 58,000 hits to our website in 2012 – of which 70% came from within Australia, followed by visitors from the United States at 9%. The News section of our website proved very popular; since October 2012, the publication of short research stories for every scientific paper with CAASTRO affiliated authors has further increased its popularity.

The CAASTRO website is our conduit for the announcement of major news and events, as well as the repository for longer-term information such as our list of members. In addition, we are also committed to an active social media presence. The CAASTRO Twitter, Facebook and YouTube accounts were recently linked to the main website, and our Twitter feed now displays on the main pages. These accounts are being reliably maintained, with frequent updates for our members and for the astronomical community in Australia and around the globe. Updates include seminar announcements, media mentions, photos of CAASTRO events or activities, new video productions and much more.

In 2012, our number of Twitter followers increased to over 300 and we sent over 600 tweets. Thanks to well-connected Twitter users like our Director Bryan Gaensler and Nobel Laureate Brian Schmidt, some of our tweets were 'retweeted' to reach more than 18,000 Twitter users.

In 2012 the CAASTRO Facebook page received over 2300 new 'likes', and an individual post to the CAASTRO Facebook page was typically seen by more than 200 people. Instrumental to our 2012 success were our close ties to the Facebook presence of the international Murchison Widefield Array (MWA) consortium and our joint outreach projects.

Our connection to the MWA team was also key in attracting viewers to our YouTube channel - to which we uploaded 23 video productions (mainly interviews and seminar recordings) in 2012. We recorded 22,466 views and an estimated 11,608 minutes of CAASTRO video material watched for the year 2012, with most viewers located in the United States. By far the most popular video, the MWA fly-through animation by Swinburne Astronomy Productions, generated almost 13,000 views in association with a MWA press release.

Presenting astronomy papers to the public
Wiebke Ebeling

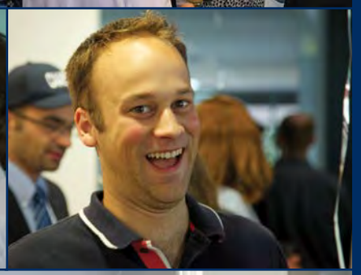
We were particularly proud to see our 'Video Press Release' of CAASTRO PhD student Morag Scrimgeour's paper "The WiggleZ Dark Energy Survey: the transition to large-scale cosmic homogeneity" quickly draw an audience of over 3,500 viewers and also stimulate an Italian spin-off video by the National Institute for Astrophysics (INAF). This paper provided evidence of large-scale homogeneity in the Universe and was also CAASTRO's most successful story in the international media in 2012, including an article in the magazine "Pour la Science" (the French version of "Scientific American"), and an interview for an Italian astronomy blog.

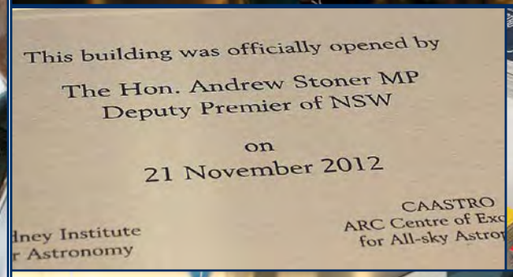
Closer to home, media highlights in the year 2012 were various interviews of CAASTRO members in the wake of the Square Kilometre Array site decision (May 2012) and the New South Wales Young Tall Poppy Award for Dr Tara Murphy at the University of Sydney (October 2012).

CAASTRO HEADQUARTERS

New Building Launch

in conjunction with
Sydney Institute for Astronomy





CAASTRO headquarters at The University of Sydney relocated on 30 April 2012. The building was opened on Wednesday 21 November 2012 by the Deputy Premier of NSW, the Hon Andrew Stoner MP, in the presence of the NSW Chief Scientist, Mary O'Kane, The University of Sydney Dean of Science, Professor Trevor Hambley, the Head of School, Professor Tim Bedding, and the Head of SIfA, Professor Peter Tuthill. Numerous CAASTRO members from a number of nodes were also present.

Emil Lenc & Deb Gooley

CAASTRO LOCATIONS

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, Bryant, Croom).
- Precision calibration of low-frequency radio data as required for detection of the Epoch of Reionisation, with a particular focus on polarisation measurements and foreground removal using the Murchison Widefield Array (MWA) (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, 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 (Bannister, Banyer, Bell, Gaensler, Hancock, Murphy, Lo).
- Automated analysis of large archival radio, optical and X-ray data sets, to identify new, rare, classes of transient sources (Bannister, Bell, Burlon, Farrell, Gaensler, Hancock, Lo, Madsen, Murphy).
- New surveys for radio variability at low frequencies, using the unique wide-field capabilities of the MWA and of the SKA Molonglo Prototype (SKAMP) (Banyer, Bell, Campbell-Wilson, Gaensler, Green, Hancock, Murphy, Thakkar).

The overall CAASTRO team at Sydney had grown to 24 people by the end of 2012, including 12 postdocs and 3 students (with several more students joining us at the start of 2013). Our research highlights for the year included:

- The first scientific results from the Sydney-AAO Multi-Object IFS (SAMI) at the Anglo-Australian Telescope, a unique instrument that deploys 13 fused fibre bundles ("hexabundles") across a one-degree field of view allowing simultaneous spatially resolved spectroscopy of 13 galaxies. During the first SAMI commissioning run, we targeted a single galaxy field, and found that one object (ESO 185-G031) had extended minor axis emission with ionisation and kinematic properties consistent with a large-scale galactic wind. The importance of this result is twofold: (1) fibre bundle spectrographs are able to identify low surface brightness emission arising from extranuclear activity and (2) such activity may be more common than presently assumed because conventional multi-object spectrographs use single-aperture fibres and spectra from these are nearly always dominated by nuclear emission. These early results demonstrate the extraordinary potential of multi-object hexabundle spectroscopy in future galaxy surveys.
- A new survey for 21-cm absorption within the host galaxies of radio sources at redshifts 1.2 to 1.5, to search for the cool neutral gas currently "missing" at redshifts $z>1$. This deficit is believed to be due to the optical selection of high-redshift objects biasing surveys towards sources of sufficient ultraviolet luminosity to ionise all of the gas in the surrounding galaxy. To avoid this bias, we selected objects above blue magnitudes $B \approx 20$, corresponding to ultraviolet luminosities below the critical value of $L_{UV} \approx 10^{23}$ W Hz^{-1}, above which 21-cm hydrogen absorption has never been detected. As a secondary requirement to the radio flux and faint optical magnitude, we shortlisted targets with radio spectra suggestive of compact sources, in order to maximise the coverage of background emission. From this, we obtained one detection out of 10 sources searched, which at a redshift $z = 1.278$ is the third highest redshift detection of associated 21-cm absorption yet made. Accounting for the spectra compromised by radio frequency interference, as well as various other possible

CAASTRO University of Sydney team members

pitfalls, we estimate a detection rate of 30%, close to that expected for sources with $L_{UV} \approx 10^{23}$ W Hz^{-1}.

- A detailed analysis of the four most widely used radio source-finding packages in radio astronomy, SEXTRACTOR, SFIND, IMSAD and Selavy. All four approaches are shown to produce source catalogues with high completeness and reliability. However, here we analysed the small fraction (1%) of cases in which these packages do not perform well. This small fraction of sources will be of concern for the next generation of radio surveys that will produce many thousands of sources on a daily basis, in particular for blind radio transients surveys. From our analysis we identified the specific ways in which the underlying source-finding algorithms fail. In response we developed a new source-finding algorithm, AEGEAN, based on the application of a Laplacian kernel, which can avoid these problems and can produce complete and reliable source catalogues for the next generation of radio surveys.

We maintained a busy outreach and education schedule throughout 2012. Our main focus was "CAASTRO in the Classroom" (CitC), a program led by Greg Madsen in which we delivered astronomy content to high schools across New South Wales via video-conferencing. More than 1000 students from 66 different schools participated in 17 separate CitC events throughout the year. Other highlights included a visit from NASA Administrator Charles Bolden in April 2012 and a public lecture from Professor Richard de Grijs (Peking University) in October 2012.

A major change in 2012 for the Sydney node of CAASTRO was a relocation. We decanted from the ageing (and now demolished) Physics Annexe on main campus, and moved into a completely refurbished large office building in Redfern. Our new CAASTRO headquarters were formally opened by the Deputy Premier of New South Wales, Andrew Stoner, on 21st November 2012. These new premises unite all of the Sydney Institute for Astronomy in a single coherent location, and provide dedicated meeting rooms, video-conferencing facilities, break-out areas and visitor space. This has allowed us to host a variety of events and workshops in-house, including "Wide-field Optical Astronomy from Antarctica" (August 2012), "The Epoch of Reionisation Global Signal" (November 2012) and the annual meeting of the CAASTRO Advisory Board (November 2012).

Several CAASTRO members at The University of Sydney received deserved recognition for their achievements in 2012: Tara Murphy was named the overall Young Tall Poppy of the Year for New South Wales, Sean Farrell was awarded the Astronomical Society of Australia's Louise Webster Prize for outstanding early-career research, Kate Gunn was named as one of Australia's 100 Women of Influence, and Paul Hancock was awarded a prestigious Curtin Research Fellowship (which he will take up in late 2013).

The University of Sydney hosts CAASTRO's main administrative office, which in 2012 consisted of Kate Gunn (Chief Operating Officer), Debra Gooley (finance), Joanne Daniels and Michelle Sullivan (executive support) and Ruth Jefferies (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 2013, 2014 and 2015, and for our next annual retreat, planned for Victoria in November 2013.

Professor Bryan Gaensler

CAASTRO Director
Themes: Dynamic, Evolving

Gaensler leads research activities in The Dynamic Universe theme at The University of Sydney. In 2012, he worked on new source-finding algorithms in continuum and in polarisation, and on data mining for transient and variable sources at radio, optical and X-ray wavelengths. In 2013, he plans to focus on extragalactic sky surveys, polarimetry and variability searches using early data from the MWA.

Associate Professor Scott Croom

CAASTRO Chief Investigator
Theme: Evolving

Croom is leading the CAASTRO project on spatially resolved optical spectroscopy using new instrumentation technology developed at The University of Sydney and the Australian Astronomical Observatory (AAO). In 2012, his team published the first papers from the Sydney-AAO Multi-object Integral field spectrograph (SAMI) on the Anglo-Australian Telescope and successfully took pilot survey observations of over 100 galaxies in several nearby galaxy clusters. At the start of 2013, Croom and his group will be commissioning an upgrade to the SAMI system to allow a substantial improvement at blue wavelengths. They will then start major observations of the main SAMI survey that will target approximately 3000 galaxies.

Professor Elaine Sadler

CAASTRO Chief Investigator
Theme: Evolving

In 2012 Sadler continued her work 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 2013 they will continue work on these nearby galaxies, and also plan to begin analysis of the first test data from ASKAP.

Professor Anne Green

CAASTRO Affiliate
Themes: Dynamic, Evolving

In 2012, Green continued as leader of the SKA Molonglo Prototype (SKAMP) project. Sections of the signal path have been tested and a new transient project is planned for 2013.

Dr James Allen

Super Science Fellow
CAASTRO Affiliate
Theme: Evolving

Allen focused on the SAMI project, developing the data reduction and analysis procedures that will be applied to the pilot and main survey data. He also contributed to the commissioning and pilot survey observations, and to developing the science case for observations of emission-line 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 neutral hydrogen to high redshifts. In 2012 Allison applied a Bayesian technique, developed for spectral-line finding and modelling in FLASH data, to observations of HI 21cm absorption with the Australia Telescope Compact Array (ATCA). He detected a particularly weak and broad absorption line, which was later confirmed with further ATCA observations. Plans for 2013 include continuation of a study of the HI content of compact radio sources selected from the AT20G survey, as well as searches in existing archival HI data.

Mr Jay Banyer

CAASTRO Professional Staff
Theme: Dynamic

Banyer continued his work on developing the VAST pipeline for automated identification of transient and variable sources, and also helped implement aspects of this algorithm into the software pipelines for ASKAP and the MWA.

Dr Martin Bell

CAASTRO Postdoctoral Researcher
Theme: Dynamic

In 2012 Bell focused on commissioning and early science from the MWA. He used observations from the MWA's 32-tile prototype to test and develop the VAST pipeline, which will allow wide-field radio searches for explosive and dynamic events in the Universe. In 2013 he hopes to publish some of this early work, and to prepare for full operations and surveys with the full MWA.

Dr Julia Bryant

CAASTRO Research Fellow
Theme: Evolving

Bryant has developed new optical imaging fibre bundles (hexabundles) for the SAMI instrument on the AAT. Following the success of the original SAMI instrument in 2012, in attaining integral field spectra (IFS) of 50 galaxies, a program has been undertaken to replace the optical fibres and hexabundles with an improved version. In order to do so, Bryant has led the team that has created these hexabundles at The University of Sydney. The instrumentation upgrade is nearly complete, and the largest IFS nearby galaxy survey to date will begin in March 2013 using SAMI. Bryant plans to use the galaxy data to study how gas gets into galaxies by correlating the gas and stellar dynamics, and by looking at kinematic disturbance as a function of galaxy environment.

Dr Davide Burlon

CAASTRO Affiliate
Theme: Dynamic

Burlon has been part of the University of Sydney team that is conducting rapid radio follow-up of gamma-ray bursts and other transient events.

Mr Duncan Campbell- Wilson

CAASTRO Affiliate
Theme: Dynamic

Campbell-Wilson is the Manager of the Molonglo Radio Observatory. Throughout 2012, he worked at Molonglo on the upgrades needed to enable the operation of SKAMP.

Dr Steve Curran

CAASTRO Research Fellow
Theme: Evolving

Curran's main interest is the study of the cool, star-forming gas in the early Universe, through the observation of hydrogen 21-cm absorption at high redshift. This can be detected in quiescent galaxies intervening the line-of-sight to a more distant quasar or within the quasar host galaxy itself. In both cases, detections at redshifts of $z > 3$ (look-back times of over 12 billion years) are very rare, although for different reasons. In 2012, Curran published a paper on each reason and is now developing these findings in preparation for the ASKAP FLASH survey. These results are also directly relevant to future 21-cm surveys with the MWA and SKA.

Dr Jamie Farnes

CAASTRO Affiliate

Since joining CAASTRO, Farnes has been organising the "CAASTRO in the Classroom" program together with Shane O'Sullivan. He hopes to help reach the project out to even more schools, and many more talks are already being planned throughout 2013.

Dr Sean Farrell

CAASTRO Affiliate
Theme: Dynamic

Farrell's specialisation is X-ray astronomy, focusing on the study of accreting compact objects (i.e. black holes, neutron stars and white dwarfs), in particular the search for intermediate mass black holes. In 2012 he worked on automatic classification of X-ray variability, and started negotiations regarding new collaborations with various high-energy telescope teams to ensure CAASTRO has access to data and expertise in this area.

Dr Paul Hancock

CAASTRO Affiliate
Themes: Dynamic, Evolving

Hancock has extended the process of visibility stacking that he developed in 2011 to radio observations of gamma-ray bursts. He has shown that most gamma-ray bursts do not have any radio emission, contrary to popular belief. Hancock has published a source finding algorithm called AEGEAN and has incorporated it into a larger piece of software that is designed to find variable and transient radio sources in large amounts of survey data. He is currently using this software to detect and characterise new and interesting transient and variable sources from observations made with the ATCA and MWA.

Dr Emil Lenc

CAASTRO Postdoctoral Fellow
Theme: Evolving

In 2012, Lenc worked as a commissioning scientist for the Murchison Widefield Array (MWA) and as Theme Scientist for CAASTRO's Evolving Universe theme. His main activities involved polarisation commissioning of the MWA, commissioning of the Real-Time System used to process MWA data and an initial search for candidate polarised point-source calibrators. As an Evolving Theme Scientist Lenc also liaised with the Theme Leader and Project Leaders to develop and complete the evolving theme project plans. In 2013, he plans to begin a full-sky survey to search for polarised point sources and diffuse polarised emission. He further plans to code and implement polarisation foreground removal within the MWA Epoch of Reionisation pipeline.

Dr Greg Madsen

CAASTRO Senior Research Fellow
Theme: Dynamic

Madsen's research focus in 2012 was exploring large historical archives of optical surveys to find large amplitude optical variables and transients. Madsen has actively contributed to several of CAASTRO's education and outreach activities, and established the innovative "CAASTRO in the Classroom" program. In 2013, he will be moving to the Astronomy Survey Unit team at the University of Cambridge in the UK.

Dr Tara Murphy

CAASTRO Associate Investigator
Theme: Dynamic

Murphy's focus is on radio observations of supernovae and gamma-ray bursts, and intelligent algorithms for detecting transient events in large volumes of data that will be produced by next-generation radio telescopes. In 2013, she plans to conduct extensive radio follow-up of extreme gamma-ray bursts, to carry out several new surveys for transients, and get the first results from the full MWA. These will provide one of the best low-frequency blind surveys for transients conducted so far.

Dr Shane O'Sullivan

CAASTRO Affiliate

O'Sullivan is one of the coordinators of the CAASTRO in the Classroom outreach program.

Mr Darshan Thakkar

Digital Engineer
Theme: Dynamic

Thakkar worked on the design and implementation of the real-time processing system for the Square Kilometre Array Molonglo Prototype (SKAMP). SKAMP will be used at CAASTRO to carry out all-sky surveys for radio variability as well as conduct experiments on RFI mitigation. In 2012, he worked on the implementation and testing of the correlation engine for SKAMP. He also worked on developing a Ten Gigabit interface for the telescope hardware that will assist in carrying out image processing of the data using high speed computers.

Ms Kitty Lo

CAASTRO Postgraduate Student
Theme: Dynamic

Lo worked throughout 2012 on development of automatic classification techniques for large-scale time-domain surveys. She has developed an approach whereby a random forest algorithm can automatically classify the variable sources in the XMM-Newton archive. She is also working on classification techniques for streaming data, which will hopefully become a part of the pipeline for the VAST survey on ASKAP. She expects to submit her thesis in mid-2013.

Mr Glen Rees

CAASTRO Student
Theme: Evolving

In 2012, Rees worked on developing new techniques for analysing sub-detection sources in radio continuum data. He compared stacked observations of VLA and 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 Postgraduate Student
Theme: Evolving

During 2012, Reeves conducted an ATCA search for intervening 21-cm hydrogen absorption in nearby galaxies, in which she simultaneously mapped the 21-cm emission from the target galaxies. By comparing the absorption- and emission-line data, she aimed to develop a better understanding of the neutral gas distribution in these galaxies. This work forms important preparation for the ASKAP FLASH survey, which will study galaxy evolution at high redshifts. In 2013, Reeves' focus will be on increasing the number of galaxies in her sample.

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 KPI and financial reporting across CAASTRO, with the aim of ensuring that CAASTRO achieves its goals and objectives.

Ms Ruth Jeffries

CAASTRO Events and Communications Officer

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

Ms Jo-Anne Daniels

CAASTRO Executive Assistant

Daniels provided executive assistance to the CAASTRO Director and other CAASTRO staff at The University of Sydney.

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.

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 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. Postdoctoral scientists employed by CAASTRO and students that are designated to CAASTRO are mixed in with other ICRAR research groups, as encouraged by the ARC. Perth-area meetings are organised every three months by Se-Heon Oh and Cathryn Trott and alternate between Curtin and UWA.

ICRAR's significant pre-existing involvement with the ASKAP and MWA radio astronomy projects required careful attention in order that CAASTRO projects are (a) self-contained and able to be separately reported; and (b) able to benefit from synergies with related ICRAR projects. An activity 'matrix' is therefore periodically updated, and all CAASTRO research activity is summarised at regular ICRAR project management meetings. This has been essential for projects like BIGHORNS for which CAASTRO provides the capital and ICRAR provides the in-kind engineering effort.

An MWA tile in outback Western Australia
Bryan Gaensler

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieve International Excellence

CAASTRO AT THE UNIVERSITY OF WESTERN AUSTRALIA (UWA)

CAASTRO UWA team members

The ICRAR-UWA node of CAASTRO is at the Ken and Julie Michael Building on Fairway in Perth. Node activities are spread across the Dynamic, Evolving and Dark themes, although mainly the latter two. Node leader Lister Staveley-Smith and Associate Investigator Martin Meyer lead or co-lead two of ASKAP's major HI galaxy surveys, WALLABY and DINGO, and one of the MWA's key themes, Galactic and Extragalactic science. The goals of these projects are to understand the evolution of our own Galaxy and galaxies in general and to probe the distribution of matter in the Universe.

Other node members during 2012 were Associate Investigator Chris Power, postdoctoral scientists Se-Heon Oh and Chris Springob, programmer Shin Kee Chung, PhD students Steven Murray, Morag Scrimgeour and Tao Hong, and administrative officer Katie Lau.

Activities this year

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

- A new ARC-funded HI and pulsar backend (HIPSR) has been deployed at the Parkes telescope, and has been used by CAASTRO researchers for several HI and pulsar projects. The system is a highly flexible hybrid FPGA/CPU/GPU system capable of wideband multibeam observations. Although it was used solely by CAASTRO, ICRAR and Swinburne researchers during 2012 commissioning, it will start to become available as a national facility in 2013. UWA researchers have been responsible for the procurement and deployment of hardware, commissioning of wideband HI observing modes, and writing of GPU narrow-band spectrometer code.

Major contributions to the Evolving science theme have been:

- Over 6 million hours of supercomputing time was awarded in 2012 to the partner Survey Simulations PipeLine (SSimPL) collaboration, of which Power is a founding member. This time was used to model cosmic structure and the influence of feedback from stars and accreting black holes on their host galaxies. Simulations of isolated and merging galaxies are being used to support SAMI galaxy survey science.
- Intensity mapping of the WiggleZ and 2dFGRS fields with the Parkes telescope to study the density and evolution of neutral hydrogen in the Universe over the last 7 billion years.
- Development of galaxy kinematic parameterisation pipelines for WALLABY and DINGO.
- Development of algorithms to decompose multi-velocity components in galaxies based on principal component analysis (PCA) and Bayesian analysis.

Major contributions to the Dark science theme have been:

- The final 2MTF spectral observations were made at Parkes and Arecibo. All GBT and Parkes observations have now been reduced, and line width measurements extracted for inclusion in the Tully-Fisher analysis.
- Peculiar velocities for the ~9000 6dFGS Fundamental Plane galaxies have been derived. Using adaptive kernel smoothing, we have produced 3D maps of the velocity field out to the 6dFGS survey limit of $z \sim 0.055$, making this the largest galaxy peculiar velocity map to date.
- Development of a new approach to quantifying the structure of dark matter haloes, which will help to differentiate between the standard Cold Dark Matter model and its alternatives.
- Cosmological simulations tracking the formation and evolution of dark matter haloes in non-standard dark matter (e.g. Warm Dark Matter) and dark energy models.

Case Study: Galaxy Kinematics

The WALLABY kinematics working group (which includes Staveley-Smith and Oh) has defined a strategy to parameterise the kinematics of spatially resolved disk-dominated galaxies from the ASKAP WALLABY and DINGO surveys. The team has designed a conceptual pipeline for extracting reliable galaxy kinematics, utilising three algorithms: ROTCUR and DISKFIT which operate on 2D velocity fields, and TIRIFIC which operates on 3D data cubes. They have tested the performance of the algorithms using a synthetic set of WALLABY-like model data cubes in a quantitative way, from which they have begun to develop pipelines for each algorithm. A pipeline for TIRIFIC has been scripted and successfully tested on real galaxies from the WHISP and LVHIS surveys. A detailed design for the ROTCUR pipeline has been made and is under development.

In parallel, a novel method has been developed for extracting velocity fields from data cubes using principal component analysis and Bayesian statistics. It enables us to decompose noisy, multi-velocity profiles into either single or multiple Gaussian components, and disentangle random and small-scale non-circular motions in galaxies from their underlying "bulk motions". A Python routine implementing the algorithm has been developed, and successfully tested on observations of the Large Magellanic Cloud to extract its bulk velocity field. This method is particularly useful for the kinematic algorithms which operate on 2D velocity fields where the extraction of reliable velocity fields is essential. Ultimately, this new velocity field extraction method will be included as a sub-routine for the WALLABY parameterisation pipeline.

Future goals

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

- Complete the ROTCUR pipeline and test on data cubes from HI galaxy surveys (LITTLE THINGS, LVHIS, THINGS) and consider testing with SAMI data.
- Complete the galaxy kinematics pipeline for WALLABY and DINGO, ready for testing on early ASKAP data cubes.
- Improve the PCA + Bayesian velocity field extraction algorithm and test it on more galaxies.
- Compilation of a synthetic SAMI galaxy survey, creating a catalogue of high resolution cosmological simulations of galaxies that can be used to interpret observed SAMI galaxies.
- Modelling the sensitivity of forthcoming extragalactic HI surveys to both the assumed dark matter model and the physics of galaxy formation.
- We will derive peculiar velocities for the 2MTF galaxies, and begin the cosmological analysis, prioritising the comparison of the velocity field with the predicted field from 2MRS.
- For 6dFGS, we will publish the velocity field cosmography results, and begin the process of folding in northern hemisphere data to complement the 6dFGS velocities in the south.
- We plan to work with CAASTRO members at Swinburne to obtain better predictions for the cosmological results from the proposed TAIPAN survey.

Professor Lister Staveley-Smith

CAASTRO Deputy Director
Themes: Evolving, Dark

Staveley-Smith has been working with WALLABY co-PI Baerbel Koribalski and other co-investigators in their preparations for this ASKAP survey. He has also been working with Tao Hong and Chris Springob on 2MTF and has led an internal call for proposals from MWA Galactic and Extragalactic Group members.

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. 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, Dark

Power has been working 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. He is also working with CAASTRO PhD student Murray to develop new tests of dark matter using supercomputer simulations of structure formation in the Cold and Warm Dark Matter models.

Dr Se-Heon Oh

CAASTRO Postdoctoral Researcher
Theme: Evolving

Oh has been working on the development of the WALLABY kinematics pipeline, particularly the pipeline for the ROTCUR algorithm and the robust velocity field extraction method based on PCA and Bayesian analysis. He has also developed and improved a pipeline for simulating synthetic HI data cubes which are used for quantitative assessments of the performance of various parameterisation algorithms. In addition, he has continued his work on the dark matter distribution in dwarf galaxies from HI galaxy surveys, addressing the central dark matter density problem in Lambda CDM simulations

Dr Chris Springob

CAASTRO Postdoctoral Researcher
Theme: Dark

Springob left the Australian Astronomical Observatory in September 2012 to join CAASTRO at UWA. He is 75% funded by CAASTRO and 25% funded by the AAO. Springob had earlier taken on the role of Dark Theme Scientist. In his new position, he works on deriving distances and peculiar velocities for the galaxies in the 2MASS Tully-Fisher Survey (2MTF). He also continues work begun on the analysis of the 6dF Galaxy Survey peculiar velocity field.

Mr Shin Kee Chung

CAASTRO Professional staff
Theme: Dynamic

Chung spent his time at CAASTRO developing a general CPU/GPU FFT and polyphase filterbank, mainly for HIPSR. He left CAASTRO in late 2012.

Ms Katie Lau

CAASTRO Administrator

Lau 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.

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 Lister Staveley-Smith and JinLin Han, and he also works closely with Chris Springob and other researchers at the AAO, CSIRO and Monash University.

Mr Steven Murray

CAASTRO Postgraduate Student
Theme: Evolving, Dark

Murray has been investigating the structure of Dark Matter haloes with supervisors Chris Power and Aaron Robotham, and co-supervisors Lister Staveley-Smith and Simon Driver. This investigation has focussed on developing non-parametric methods of describing the global shape of a dark matter halo, using an adapted two-point correlation function. He has also developed an interactive web-application which calculates the Halo Mass Function for an input cosmology. Murray intends to utilise the non-parametric methods he has developed to test whether dark matter is 'cold' or 'warm', by looking for statistical differences using large-scale dark matter simulations.

Ms Morag Scrimgeour

CAASTRO Postgraduate Student
Theme: Dark

Scrimgeour works on dark matter and cosmology. She is supervised by Lister Staveley-Smith, Peter Quinn (UWA) and Tamara Davis (University of Queensland), but also works with CAASTRO investigators Brian Schmidt and Chris Blake. She is currently working on new analysis techniques for peculiar velocities and simulations of the SkyMapper survey supernova survey.

Curtin University

CAASTRO AT CURTIN UNIVERSITY

Astrophysics research at Curtin University is a relatively new enterprise. The home of CAASTRO at Curtin University is the Curtin Institute of Radio Astronomy (CIRA), established in 2007 and led by two foundation Professors, Steven Tingay (Physics) and Peter Hall (Engineering). Curtin's investment in establishing CIRA was motivated by Australia's involvement in the Square Kilometre Array (SKA) project and the possibility that the SKA could be located in Western Australia. With the SKA site decision announced on 25 May 2012, awarding part of the instrument to Western Australia, this aspiration was realised and will provide the platform for further growth and investment in CIRA over coming years.

The purpose of CIRA as a multi-disciplinary institute is to fuel innovative approaches to radio astronomy by working at the nexus of science and engineering, and by tackling challenging research problems on the path to the SKA. CIRA's involvement in CAASTRO is an important element of this approach.

Curtin University is also the lead institution in the $50 million Murchison Widefield Array project, an SKA precursor telescope constructed by an international consortium at Australia's candidate SKA site in the Murchison region of Western Australia. The MWA, the main instrument that will enable CAASTRO Epoch of Reionisation (EoR) research, has completed its final stage of construction and will be fully operational for science in mid 2013. The coming year will therefore be a landmark year for the MWA and for CAASTRO's Evolving Universe theme, as the first MWA data for the EoR flow.

The ICRAR-Curtin CAASTRO team is led by Professor Tingay, CAASTRO Chief Investigator and CAASTRO Executive member with carriage of Education & Outreach (see the Education and Outreach section in this Annual Report for an overview). The last year of CAASTRO at Curtin has been one of consolidation of the core team and expansion of staff, with CIRA hosting 16 CAASTRO staff and students. In addition to the nine staff and students listed in the 2011 Annual Report, 2012 has seen the addition of: Dr Ramesh Bhat (Dynamic Theme; Associate), Mrs Angela Dunleavy (Administrative Coordinator), Mrs Rachel Kennedy (Administrative Assistant), Dr Stephen Ord (Dynamic Theme; Associate), Mr Samuel Oronsaye (Dynamic Theme; PhD student), Dr Marcin Sokolowski (Evolving Universe Theme; CAASTRO Postdoctoral Fellow), and Mrs Roselina Stone (Administrative Assistant).

CAASTRO members at Curtin University are involved in the following science projects:

The Evolving Universe

The EoR Global Signal experiment aims to detect the faint signal from neutral hydrogen that is expected to be present over the entire sky from the period in the early Universe call the Epoch of Reionisation. The signal can, in principle, be detected by a single, very well calibrated radio antenna and receiver working in the 50-250MHz range of the radio spectrum. The detection of this signal will be one of the next major advances in cosmology. It is a challenging experiment because the signal to measure is many times fainter than other naturally occurring radio signals from our Galaxy.

This year, a CAASTRO sponsored workshop on the EoR Global Signal experiment was held at CAASTRO headquarters in Sydney, drawing together researchers working in the field from Australia, the US, Europe and India for the first time (organised by CAASTRO Curtin Associate Investigator Dr Randall Wayth). The workshop highlighted two of the big challenges in executing this experiment: 1) the effects of the ionosphere; and 2) our imperfect knowledge of the spectral signature of the galactic foreground. The workshop was very useful and has prompted significant thinking regarding the questions raised, which will inform our CAASTRO experiment over the next 12 months.

This project is engaging with industry partner Poseidon Scientific Instruments to design a high precision analogue receiver system using a CSIRO designed digital backend. This system will be a mobile, self-contained observatory. The last year saw the first data collected with this system, at the Muresk test location, approximately 80 km north-east of Perth, as well as a reconnaissance trip into the far outback of Western Australia to find the most radio quiet location for the final experiment. (Mossammaparast, Sokolowski, Tingay, Tremblay, Wayth)

In addition, CAASTRO Postdoctoral Fellow Dr Cathryn Trott has been making some very significant contributions to the very hot field of EoR power spectrum detection using interferometric instruments such as the MWA. Dr Trott is bringing a new way of looking at interferometric data, from an Information Theory perspective, to this problem and in the coming year aims to publish a substantial paper on the topic, in preparation for the first data from the MWA. (Tingay, Trott, Wayth)

CAASTRO Curtin University Team members

The Dynamic Universe

Curtin CAASTRO members are heavily involved in designing smart algorithms for sifting through data at the enormous (>20 Terabit per second) rates expected from next-generation widefield radio telescopes in order to detect and localise transient objects. Indeed, this area of CAASTRO research at Curtin has seen the largest growth in numbers of staff and students, with the addition of two CAASTRO Associates (Bhat and Ord) and a CAASTRO PhD student (Oronsaye) in the last year.

New algorithms are vital because current brute-force methods of searching for short timescale (<1 second) transients requires us to correct for the effects of interstellar and intergalactic dispersion which can balloon the data rate out by a further factor of hundreds. If the entire field of view of the telescope is to be searched for transients at the full array sensitivity, this can cause a further factor of 100 explosion in the data rate.

Dr Trott and Dr Macquart are designing and testing new algorithms that circumvent much of the computational effort required to de-disperse and localise fast radio transients. They are collaborating with members of the LOFAR transients key project to test out their ideas on telescopes whose design may closely resemble the aperture arrays deployed as part of the low-frequency component of the SKA. Dr Trott is also working on detection of slow transients in the u-v domain, an approach which promises to extract transient signals at a sensitivity just above the thermal noise of a radio array. This approach possesses an enormous advantage when the area of sky being searched is extremely crowded (e.g. regions of intense interest such as that at the Galactic centre).

Dr Trott has applied some of these ideas in a re-interpretation of data from a fast transient detection experiment led by Prof. Tingay, with the results to be published next year.

New Associates Dr Bhat and Dr Ord, along with new PhD student, Mr Oronsaye, are developing techniques for the detection and timing of pulsars using the MWA, requiring similar instrumental capabilities to those used for fast transient experiments. (Bhat, Macquart, Ord, Oronsaye, Tingay, Tremblay, Trott).

Professor Steven Tingay

CAASTRO Chief Investigator, Node Leader, Executive Member (Education & Outreach)
Themes: Dynamic, Evolving

In 2012 as a member of the CAASTRO Executive, Tingay put a lot of time into progressing the CAASTRO science programs and consolidating the Centre and the Curtin University node. On the science front, he has been working on the Evolving Universe theme project to build a sensitive radio telescope to detect the signals arising from the first stars and galaxies in the Universe, from the so-called Epoch of Reionisation (EoR). In the Dynamic Universe theme, Steven and others are establishing a unique fast transient detection capability using the Murchison Widefield Array.

Dr Ramesh Bhat

CAASTRO Associate Investigator
Theme: Dynamic

Bhat works in the area of observational pulsar astronomy and the transient radio Universe. In 2012, his research focused on technical and science demonstration experiments related to high time resolution astrophysics in the SKA-era, and the development of high time resolution science capabilities for the upcoming MWA. He is a member of the science commissioning team for the MWA that will open up new science avenues in the areas of pulsars and transients. In 2013, he will continue these activities, as well as taking part in the ongoing high time resolution surveys at Parkes, which continues to make exciting discoveries of new pulsars and transient sources.

Dr Wiebke Ebeling

CAASTRO Education & Outreach Coordinator

Throughout 2012, Ebeling has been looking after the CAASTRO website and Social Media channels with frequent and relevant information for the astronomical community. She was involved in issuing nine press releases about CAASTRO publications and outreach events, two of which were accompanied by short videos that she had produced, and she authored eleven research stories for papers with a CAASTRO author affiliation. She continued to coordinate all CAASTRO outreach activities, for instance the Musica Viva pre-concert talks in six Australian capitals and contributions to National Science Week in Melbourne, Perth and Geraldton. Ebeling represented CAASTRO at two major science communication conferences in 2012 and was elected Vice-President of the Western Australian branch of Australian Science Communicators.

Dr Jean-Pierre Macquart

CAASTRO Associate Investigator
Theme: Dynamic

Much of Macquart's output in 2012 related to the use of interstellar scintillation as an ultra-high resolution probe of distant black holes. One highlight was the derivation of structure in the quasar PKS 1257-326 on a scale down to a fraction of a micro-arcsecond. Proving that the technique applies to small and large black holes alike, he applied the same technique to derive the size of a micro-quasar located in the nearby Andromeda galaxy. The remainder of his efforts centred around the development of new techniques to detect radio transients on millisecond to nanosecond time resolutions.

Mr Mehran Mossammaparast

CAASTRO Postgraduate Student
Theme: Evolving

During 2012, Mehran built and tested two prototype radiometers, each consisting of a front-end module and a gain module, for the EoR Global Signal project (BIGHORNS). The radiometer was initially tested in the laboratory. To complete the signal path for the field deployment, the front-end module attaches directly to a prototype discone antenna. The gain module is integrated into the data acquisition back-end system which then connects to the front-end module via a 100m RF cable. Some initial field tests were carried out and will be continued in 2013.

Dr Stephen Ord

CAASTRO Associate Investigator
Theme: Dynamic

In collaboration with Tremblay and Bhat, Ord has been developing the high time resolution capability of the MWA. This will enable the telescope to observe pulsars and rapid transients. He was also developing pulsar survey algorithms and techniques for use with sparse arrays like the MWA and the SKA. This work will provide the framework supporting Samuel Oronsaye's PhD program.

Mr Samuel Oronsaye

CAASTRO Postgraduate Student
Theme: Dynamic

Oronsaye started his PhD project in 2012 by learning some pulsar software packages, working on his candidacy proposal, and searching for pulsars in the data from the 32-tile MWA with the incoherent beam. In 2013, he will submit his candidacy proposal, learn more software packages, and perform pulsar searches with the coherent beam, on the MWA 32-tile, and subsequently 64-tile and the whole 128-tile system.

Dr Marcin Sokolowski

CAASTRO Postdoctoral Fellow
Theme: Evolving

Since the beginning of 2012 when he joined CAASTRO, Sokolowski has been involved in the development and lab and field tests of the BIGHORNS system – a total power radiometer system designed to observe the global signature of the Epoch of Reionisation (EoR). He was working on the software and analysis of preliminary data collected at Muresk 80km north-east from Perth and from a few remote locations in the South of Western Australia during excursions to find the best possible site for collection of RFI-free EoR data. His plans for 2013 are to further improve the system's calibration, deploy the system in the remote location and analyse the new data in order to obtain constraints on the EoR signal.

Dr Steven Tremblay

CAASTRO Postdoctoral Fellow
Theme: Dynamic

In 2012, Tremblay delineated and oversaw the purchase of the hardware required to record Fast Transient observations with the MWA. This system will be used to observe pulsars, RRATs, and solar transients as well as other exotic phenomena. Additionally, Steven contributed to the hardware development and oversaw the field testing of the BIGHORNS Global EoR Experiment throughout the year. At the end of the year, he participated in a five day RFI survey, scouting for the most radio quiet sites in Western Australia. He was also appointed as the inaugural Dynamic Universe Theme Scientist in 2012.

Dr Cathryn Trott

CAASTRO Postdoctoral Fellow
Themes: Dynamic, Evolving

During 2012, Trott continued her work in the Dynamic Theme developing algorithms for detecting and localizing slow and fast radio transients. As part of this work, she designed and published a new methodology for interpreting the results of fast transients search experiments, extending previous work in the field. She applied this framework to recent data from the V-FASTR VLBA experiment. Trott's work in the Evolving Theme has focussed on designing and implementing an Epoch of Reionisation estimation algorithm, for application to data from the Murchison Widefield Array (MWA) instrument. She is also continuing her collaborative projects, working with medical physicists from Harvard to evaluate the utility of new medical imaging techniques for estimating the size and location of tumours.

Dr Randall Wayth

Associate Investigator
Theme: Evolving

Wayth is the Project Manager for the BIGHORNS EoR Global Signal project. Wayth managed the procurement of RF, signal processing and fieldwork equipment required for deployment of BIGHORNS in remote locations. He is co-supervisor of Masters student Mehran Mossammaparast.

Mrs Angela Dunleavy

Administrative Coordinator
Dunleavy provides administrative support to the CAASTRO team at Curtin and contributed to the successful running of the 2012 CAASTRO Annual Retreat at Cervantes.

Ms Tina Sallis

Finance Manager

Sallis has been responsible for financial support to the CAASTRO team members at Curtin and for reconciliation of financial data against the CAASTRO budget.

Mrs Roselina Stone

Administrative Assistant

Stone joined the administration team at Curtin in August 2012 to provide administrative support to members at the Curtin CAASTRO node.

Mrs Rachel Kennedy

Administrative Assistant

Kennedy assisted the Curtin node administration with event management, travel arrangements, and welcoming visitors.

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 science:

- 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)
- Numerical simulation of the evolution of early galaxies and their interaction with the high redshift intergalactic gas (Wyithe, Tescari, Jeeson-Daniel, Bolton, Kim, Katsianis, Bruns)
- Studies of the properties of elliptical galaxies from the 6df redshift survey (Magoulas)

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).

2012 saw a continued ramp up of activity at Melbourne in all these areas – the CAASTRO team now numbers more than 19 people, including 5 postdocs and 4 PhD students.

Amongst our research highlights for the year were:

- Large surveys for Lyman-alpha emitting (LAE) galaxies have been proposed as a new method for measuring clustering of the galaxy population at high redshift with the goal of determining cosmological parameters. However, Lyman-alpha radiative transfer effects may modify the observed clustering of LAE galaxies in a way that mimics gravitational effects, potentially reducing the precision of cosmological constraints. During 2012 we have looked at quantifying this effect. For example, the effect of the linear redshift-space distortion on the power spectrum of LAE galaxies is potentially degenerate with Lyman-alpha radiative transfer effects owing to the dependence of observed flux on intergalactic medium velocity gradients. We have shown that the three-point function (bispectrum) can distinguish between gravitational and non-gravitational effects, and thus breaks these degeneracies, making it possible to recover cosmological parameters from LAE galaxy surveys. Constraints on the angular diameter distance and the Hubble expansion rate can also be improved by combining power spectrum and bispectrum measurements. [Greig, Wyithe]
- 2012 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. These developments include:
  - A visibility gridding option that uses kernels that contain antenna primary beam information. This will become increasingly important as we push sensitivity and high dynamic levels.
  - Generation of integrated Stokes V images and full-Stokes intermediate snapshot output.
  - Frequency derivative matrices are now pre-computed for each pixel, along with the polarised weight matrices. This allows the primary beam shape to change with frequency within each snapshot.
  - Polarised weight matrices can now be regridded and stored with the integrated RTS images, significantly decreasing post-processing time.
  - A form of multi-frequency synthesis is available in CPU mode.
  - A new front end is being tested to enable direct ingestion of correlator output.
  - The RTS has been installed on the Fornax GPU cluster, where it is routinely used to process commissioning data.
  - Tools have been created to process a list of observations (correlator files to integrated images) using information in the monitor and control archive.
  - Deeply peeled images that are close to the confusion level have been made with little user input, and are under investigation. (Mitchell, Webster, Pindor, Procopio)

CAASTRO University of Melbourne team members

- During 2012 we explored the process of wide-field synthesis imaging with the aim of understanding the implications of variable, polarised primary beams for forthcoming Epoch of Reionisation experiments. These experiments seek to detect weak signatures from redshifted 21 cm emission in deep residual datasets, after suppression and subtraction of foreground emission. Many subtraction algorithms benefit from low side-lobes and polarisation leakage at the outset, and both of these are intimately linked to how the polarised primary beams are handled. Building on previous contributions from a number of authors, in which direction-dependent corrections are incorporated into visibility gridding kernels, we considered the special characteristics of arrays of fixed dipole antennas operating around 100-200 MHz, looking towards instruments such as the Square Kilometre Array (SKA) and the Hydrogen Epoch of Reionisation Arrays (HERA). We showed that integrating snapshots in the image domain can help to produce compact gridding kernels, and also reduce the need to make complicated polarised leakage corrections during gridding. We also investigated an alternative form for the gridding kernel that can suppress variations in the direction-dependent weighting of gridded visibilities by 10 s of dB, while maintaining compact support. (Mitchell)
- During 2012 we executed a new state-of-the-art program of cosmological hydrodynamical simulations to better understand the interplay between galaxies and intergalactic medium (IGM) from redshift $z \sim 2$ to the epoch of reionisation at $z = 6$ and above. In the next few years, 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 guiding future observational programs. We have made substantial progress towards this goal, combining a large grid of photoionisation modelling with hydro-dynamical modelling of galactic star formation and star formation driven outflows. Our theoretical program is being used to interpret observations of the transverse proximity effect and metal lines in close proximity to foreground galaxies. (Tescari, Bolton, Schmidt, Singh, Wyithe)
- During 2012 we have also executed a new cosmological hydrodynamical simulation program aiming to study the role of feedback in regulating star formation in the highest redshift galaxies. 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 hydrodynamical simulations and including different physical properties for the feedback we have modelled the stellar mass function and star formation rate function for comparison with observations. (Tescari, Bolton, Katsianis, Wyithe)
- During 2012 we investigated the impact of feedback - from supernovae (SNe), active galactic nuclei (AGN) and a photoionising background at high redshifts - on the neutral atomic hydrogen (HI) mass function, the galaxy luminosity function, and the spatial clustering of these galaxies at $z = 0$. Using a semi-analytical galaxy formation model we found that a systematic increase or decrease in the strength of SN feedback leads to a systematic decrease or increase in the amplitudes of the luminosity and HI mass functions, but has little influence on their overall shapes. On the other hand, varying the strength of AGN feedback influences only the numbers of the brightest or most HI massive galaxies. The impact of varying the strength of photoionisation feedback is restricted to changing the numbers of the faintest or least HI massive galaxies. Thus our results suggest that the HI mass function is a more sensitive probe of the consequences of cosmological reionisation for galaxy formation than the luminosity function. Our results also indicate that forthcoming HI surveys on next-generation radio telescopes such as the Square Kilometre Array and its pathfinders will be exploited most fruitfully as part of multiwavelength survey campaigns. (Kim, Wyithe)
- During 2012 we studied how measurements of the intergalactic medium (IGM) temperature provide a potentially powerful constraint on the reionisation history due to the thermal imprint left by the photoionisation of neutral hydrogen. Until recently, IGM temperature measurements were limited to redshifts $2 \leq z \leq 4.8$, restricting the ability of these data to probe the reionisation history at $z > 6$. We used recent measurements of the IGM temperature in the near-zones of seven quasars at $z = 5.8$-6.4, combined with a semi-numerical model for inhomogeneous reionisation, to establish new constraints on the redshift at which hydrogen reionisation completed. We calibrated the model to reproduce observational constraints on the electron scattering optical depth and the HI photoionisation rate, and compute the resulting spatially inhomogeneous temperature distribution at $z \sim 6$ for a variety of reionisation scenarios. We found that the near-zone temperature measurements constrain the redshift by which hydrogen reionisation was complete to be $z_r > 7.9$ (6.5) at 68 (95) per cent confidence. (Bolton, Wyithe)

Also in 2012, members of the Melbourne node continued to roll-out the innovative "Telescopes in Schools" program that has purchased ten 30-cm telescopes with a range of accessories to be loaned to underprivileged schools across Melbourne. This project has trained science teachers in each school on the use of the equipment and support will be provided on a range of suitable learning objectives for students in Years 7-9. We also contributed strongly in more traditional outreach and education activities throughout 2012 – from public lectures through to our work experience program.

The team at Melbourne was very ably assisted in their year's work by executive officer Kim Dorrell who very efficiently managed local node affairs while contributing to the organisation of national events like the CAASTRO-wide staff retreat at Cervantes, WA.

Professor Stuart Wyithe

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

In 2012, Wyithe worked on studying the effect that fluctuations in transmission of Ly-alpha from high redshift galaxies would have on studies of clustering in Ly-alpha emitters, and on simulations of the stellar mass function in high redshift galaxies. In 2013, he plans to work on incorporating results from the Ly-alpha transmission studies with numerical simulations.

Professor Rachel Webster

CAASTRO Chief Investigator
Theme: Evolving

During 2012 Webster concentrated her efforts towards working with the MWA team on preparations for the MWA Epoch of Reionisation experiment. Next year she will work on implementation of the Epoch of Reionisation program, and on studies of weak lensing with SAMI.

Dr Jamie Bolton

CAASTRO Associate Investigator
Themes: Evolving, Dark

In 2012 Bolton worked with PhD student Brad Greig on developing simulations to calculate the effect of temperature fluctuations on the absorption statistics towards quasars. In October 2012, Bolton relocated to the University of Nottingham where he has taken up a lectureship.

Dr Daniel Mitchell

CAASTRO Research Fellow
Theme: Evolving

Throughout 2012, Mitchell carried out the majority of the RTS developments and updated a number of post-processing routines. Running on up to 24 parallel GPUs of the Pawsey cluster, Fornax, he and a small RTS commissioning team used the software to process data coming from the MWA commissioning campaigns, and worked to commission the RTS itself as a stream processor of archived visibilities. He was active in the MWA science commissioning team, attending several busy weeks and international project meetings. He also gave an invited talk at the Numerical Cosmology conference at the University of Cambridge, and published a paper on wide-field polarised imaging.

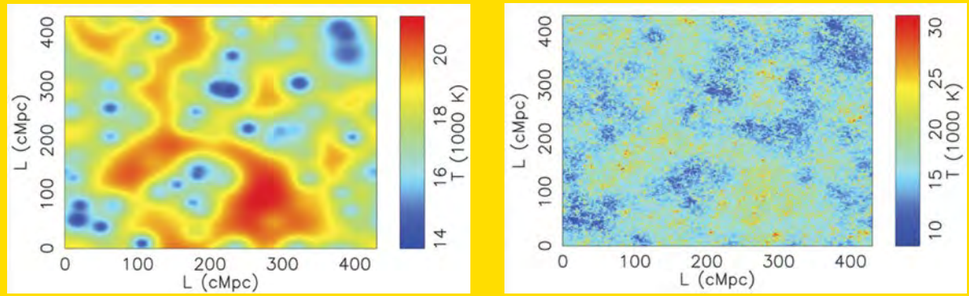
Dr Edoardo Tescari

CAASTRO Postdoctoral Fellow
Theme: Evolving

In 2012 Tescari initiated a large program to numerically simulate high redshift galaxies, with the goal of studying the effects of feedback on the star-formation rate function. During 2013 Tescari will lead the running and analysis of this simulation program, and focus on simulations to study the relation between feedback and metals in the intergalactic medium.

Year 10 students attending a week-long work experience program sponsored by CAASTRO, present their chosen research topics to the Melbourne Astrophysics group

Kim Dorrell



This figure shows a simulation slice of the IGM temperature in the presence of a quasar ionising background

Top left: IGM temperature assuming a homogeneous gas distribution and

Top right: IGM temperature assuming an inhomogeneous gas distribution

CAASTRO PhD student Brad Greig is using simulations like these to investigate the effect of temperature fluctuations on the ability of experiments using absorption spectra to probe the baryon acoustic oscillation scale

Dr Pietro Procopio

CAASTRO Postdoctoral Fellow
Theme: Evolving

Procopio joined CAASTRO in early 2012 and has been working with MWA 32T data, running the calibration and imaging pipeline. He is a member of the MWA Science Commissioning Team, carrying out comparison between the RTS and CASA. He is currently implementing most of the steps that are required to perform forward modelling into the RTS code.

Dr Akila Jeeson-Daniel

CAASTRO Postdoctoral Fellow
Theme: Evolving

Jeeson-Daniel joined CAASTRO at the end of 2012, and has initiated studies of the environmental dependence of Ly-alpha transmission using numerical simulations. In 2013 she will use this work to investigate the effects on studies of clustering in Ly-alpha selected galaxy samples.

Mr Bradley Greig

CAASTRO PhD student
Theme: Dark

During 2012 Greig's focus was on calculation of how intergalactic absorption effects the clustering of Ly-alpha emitting galaxies, employing higher order statistics. In 2013 Greig will focus on submitting his PhD, before moving to Scuola Normale Superiore, Italy as a postdoctoral fellow.

Ms Sinem Ozbilgen

CAASTRO MSc student
Theme: Dark

Commencing in 2012, Ozbilgen's project will obtain WiFeS IFU cubes of a sample of HIPASS galaxies to determine whether bulge/total luminosity is a good proxy for galaxy type, and whether the inclusion of the bulge velocity dispersion can reduce the scatter in the TFR. Her work will contribute to the Dark theme program's goal to map the cosmic flows in the local universe.

Mr Loren Bruns Jr

CAASTRO PhD student
Theme: Evolving

In 2012 Bruns focused on completion of his PhD thesis studying the effect that a quasar has on the observed properties of nearby Ly-alpha selected galaxies. He will submit this in early 2013.

Ms Christina Magoulas

CAASTRO PhD student
Theme: Evolving

In 2012 Magoulas completed her PhD thesis on the properties of elliptical galaxies and the fundamental plane using the 6dF galaxy redshift survey.

Ms Jennifer Riding

CAASTRO PhD student
Theme: Evolving

Riding was active in the MWA science commissioning team throughout 2012 and attended a number of busy weeks. Her PhD work was centred around using shapelets to characterise compact radio sources that are resolved by the MWA. She has been concentrating on strong sources such as Fornax A, which need to be carefully modelled so that they do not contaminate MWA EoR measurements.

Mr Antonios Katsianis

CAASTRO PhD student
Theme: Evolving

Katsianis began his PhD during 2012 studying the properties of high redshift galaxies via numerical simulation. He is focussed on calculating the stellar mass function and star formation rate function from the CAASTRO suite of simulations. In 2013 he will focus on interpreting what these simulations imply for the feedback mechanisms important in high redshift galaxies.

Miss Nastaran Rezaee

CAASTRO MPhil student
Theme: Evolving

During 2012 Rezaee began her MPhil studying the characterisation of noise in MWA images using simulations in comparison with early MWA data. In 2013 she will concentrate on finishing her thesis.

Dr Han-Seek Kim

CAASTRO Affiliate
Theme: Evolving

During 2012 Kim finalised development of a new code that incorporates semi-numerical study of reionisation structure into the semi-analytic code Galform using the Millenium-II simulation, and used this to study the effect of supernova feedback and radiative suppression on the 21cm power spectrum from reionisation. In 2013, Kim will extend this work to produce reionisation maps within much larger simulation volumes.

Dr Bart Pindor

CAASTRO Affiliate
Theme: Evolving

During 2012 Pindor has been working on supporting the MWA RTS commissioning effort. Pindor adapted Python-based MWA analysis tools to create a data processing pipeline on IVEC's GPU-based Fornax cluster which allows for efficient processing of large volumes of MWA data. Pindor will continue to work on MWA data pipelines and algorithms as the MWA moves into 128T commissioning and early operations.

Dr Alan Duffy

CAASTRO Affiliate
Themes: Evolving, Dark

Joining in November 2012, Duffy is working on reionisation physics as well as continuing his long standing collaborations with ASKAP and ICRAR in creating bespoke radio predictions for Dark Matter and galaxy formation models. He is also working with collaborators to create next-generation simulations that will lead to world-class simulation schemes for probing the Dark universe.

Dr Katherine Mack

CAASTRO Affiliate
Themes: Evolving, Dark

Commencing in December 2012, Mack will work 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 will form new collaborations within CAASTRO aiming to connect observational and numerical projects to new theoretical developments.

Ms Catherine De Burgh-Day

CAASTRO 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 will be fully testing and calibrating the DSM fitting algorithm, obtaining pilot SPIRAL observations to test the methodology, simulating the expected distribution of lenses for a ΛCDM model, developing a project based on the SAMI survey to make DSM measurements in the local universe, and using these observations to measure individual DM haloes as well as measure various parameters in the standard cosmological model.

Ms Kim Dorrell

CAASTRO Executive Officer

Throughout 2012, Dorrell continued to provide broad administrative advice and support to the expanding team at UMelb. She is responsible for all financial processing and reporting for the node. She also provides policy and procedural advice and assistance to local staff and students regarding human resources, student administration, travel arrangements, visitors, and events management including coordinating the Year 10 work experience program.

CAASTRO AT SWINBURNE UNIVERSITY OF TECHNOLOGY

CAASTRO Swinburne University of Technology Team members

2012 was a time of transition for the Dynamic Theme, and a time of consolidation for the Dark Theme at Swinburne University of Technology.

Two CAASTRO-related PhDs were completed in 2012. Dr Lina Levin completed her PhD entitled "A Search for Radio Pulsars: from Millisecond Pulsars to Magnetars". Dr Ben Barsdell also completed his thesis entitled "Advanced Architectures for Astrophysical Supercomputing". These students were replaced by Ms Emily Petroff, from Carleton College who has commenced her thesis on a very relevant Dynamic theme topic, "The Dynamic Galaxy".

Two new Postdoctoral staff were hired in 2012: Dr Evan Keane and Dr Ewan Barr, both from the Max Planck Institute for Radio Astronomy. Evan and Ewan will commence in August and March 2013 respectively and their recruitment is a testament to the value CAASTRO's external partners provide, where they both currently work.

A flurry of activity around apparently cosmologically-distant millisecond duration radio bursts took place in the second half of 2012, with an exciting announcement of the best "Lorimer Burst" yet detected in the High Time Resolution Universe survey at the Beijing IAU meeting.

In the Dark Theme, the outstanding highlight was the work of the WiggleZ collaboration, with science lead Associate Professor Chris Blake. Chris and his collaborators wrote a series of high-impact papers that resulted in Chris being awarded the prestigious 2013 Pawsey Medal.

In the Evolving Theme, Professor Jeremy Mould and his students made progress on distance indicators.

In 2013 Professor Warrick Couch will leave Swinburne to take up the prestigious post of AAO Director but remain an Adjunct of the University.

Professor Matthew Bailes

CAASTRO Chief Investigator and Dynamic Universe Theme Leader
Theme: Dynamic

In 2012, Bailes oversaw the modernisation of the pulsar instrumentation at the Parkes telescope and was part of a team that has discovered a large number of millisecond-duration bursts of radio emission using the same instrument that appear to be at cosmological distances.

Dr Ramesh Bhat

CAASTRO Postdoctoral Researcher
Theme: Dynamic

Dr Bhat works in the area of observational pulsar astronomy and the transient radio universe. In 2012, he commenced a mammoth undertaking of searching some 100 terabytes of data from the Giant Metrewavelength Radio Telescope (GMRT) for transients. The GMRT is the largest fully-steerable dish array in the world and Bhat used Swinburne's supercomputer to process these data using some novel new techniques that excise radio frequency interference to reveal transient sources. He won a prestigious Curtin Research Fellowship and moved to the Curtin node in May 2012 where he remains an active member of CAASTRO.

Dr Jonathon Kocz

CAASTRO Postdoctoral Researcher
Theme: Dynamic

An expert on radio frequency interference mitigation and instrumentation, Dr Kocz worked on new modes of observation for the Parkes telescope that enabled modernisation of the instrument with Andrew Jameson, a CAASTRO software engineer. Kocz was successful in winning a postdoctoral fellowship to the Harvard-Smithsonian Center for Astrophysics to work on the Epoch of Reionisation and left CAASTRO in early 2012.

Dr Willem van Straten

CAASTRO Affiliate
Theme: Dynamic

Dr van Straten is an expert in high-precision pulsar timing, and has developed state-of-the-art instrumentation and high-performance data analysis software for the world's premiere radio observatories. In 2012, he was involved in the High Time Resolution Universe survey project based at the Parkes Observatory that discovered a large number of millisecond pulsars, and worked on developing a search technique for finding accelerated neutron stars in the High Time Resolution Universe survey data.

Mr Andrew Jameson

CAASTRO Software Engineer
Theme: Dynamic

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

Dr Ben Barsdell

CAASTRO Student
Theme: Dynamic

Barsdell completed his PhD under the supervision of Matthew Bailes in collaboration with Chris Fluke and David Barnes on applications of Graphics Processing Units in astronomy. For his PhD Barsdell developed highly-efficient codes that process pulsar data in real time opening up new areas of discovery space. His PhD was awarded in 2012 and he has been appointed to a postdoctoral position at the Harvard-Smithsonian Center for Astrophysics in Boston, Massachusetts.

Dr Lina Levin

CAASTRO Student
Theme: Dynamic

Levin completed her PhD under the supervision of CAASTRO's Matthew Bailes, Willem van Straten and Michael Kramer in collaboration with Dr Simon Johnston (CSIRO) on the topic of millisecond pulsar surveys and magnetars. In her thesis Levin presented a population study of the Galactic population of millisecond pulsars, and a very large number of new objects. Her PhD was awarded in 2012 and she took up a postdoctoral position at the University of West Virginia.

Ms Emily Petroff

CAASTRO Student
Theme: Dynamic

Petroff commenced her PhD in 2012 with Willem van Straten and Matthew Bailes as supervisors. She is using the dispersive properties of the interstellar medium in combination with observations of pulses of radio emission to learn about both the pulses themselves and the interstellar medium. Her first project was in collaboration with the pulsar team at CSIRO led by Simon Johnston and it used archival pulsar timing data to examine how the dispersion of pulsars varies (or doesn't) with time, and how this can be used to determine the nature of the interstellar medium. She has also helped to assemble a 200TB dataset on disk to search for Lorimer bursts from cosmological distances.

Professor Jeremy Mould

CAASTRO Chief Investigator
Themes: Dark, Evolving

During 2012 Mould and two CAASTRO students discovered improvements to two extragalactic distance indicators. The celebrated supernova standard candle is improved by measuring supernova brightness in the infrared (rest frame). The Tully Fisher relation is improved by measuring the velocity dispersion of the galaxy's bulge as well as its rotation velocity.

Professor Karl Glazebrook

CAASTRO Affiliate
Themes: Dark, Evolving

Glazebrook's main CAASTRO activity was the negotiation of a MOU between a group of CAASTRO researchers ('the OzDES team') and the international Dark Energy Survey Team. OzDES will access their new deep wide field imaging survey for AAOMega spectroscopic follow-up on the AAT.

Dr David Lagattuta

CAASTRO Postdoctoral Researcher
Theme: Dark

Lagattuta published the first results from SHARP, a project that combines gravitational lensing and high-resolution imaging to search for dwarf satellite galaxies beyond the Local Universe, in an effort to constrain small-scale substructure mass predictions from Lambda-CDM models. He also led efforts on WISE TF, a new all-sky Tully Fisher relation constructed, for the first time, at mid-infrared wavelengths. In addition, Lagattuta was part of the team that enabled CAASTRO to join the new PanSTARRS collaboration, an instrument which will be a valuable northern hemisphere counterpart to SkyMapper.

Dr Eyal Kazin

CAASTRO Postdoctoral Researcher
Theme: Dark

Kazin is playing a leading role in data analysis for the two most powerful current large-scale structure surveys, the WiggleZ Dark Energy Survey and Baryon Oscillation Spectroscopic Survey (BOSS).

Dr Kazin has applied the technique of "density-field reconstruction" to the WiggleZ dataset, resulting in significant (provisional) improvements in our distance-scale measurements using the baryon acoustic peak. He has completed a thorough analysis of anisotropic galaxy clustering in BOSS, resulting in soon-to-be-published new measurements of the Hubble expansion rate at redshift $z = 0.6$.

Mr Syed A Uddin

CAASTRO Postgraduate Student
Theme: Dark

As part of the collaboration with Dark Energy Survey (DES), Uddin has been involved in spectroscopic follow-ups with AAOmega on AAT for supernovae candidates discovered with DECam on the Blanco telescope. Uddin's PhD thesis is on deriving cosmological parameters using Type Ia supernovae that are hosted in early type galaxies.

Professor Warrick Couch

CAASTRO Chief Investigator
Themes: Dark, Evolving

Couch oversaw the "Dark Universe" research that is being done at Swinburne as part of the WiggleZ Dark Energy Survey, and played a significant role in establishing the SAMI Galaxy Survey and defining its "morphological transformation" science program. The main priority for the former was to finalise and publish the key cosmology results, as well as to obtain improved, higher precision BAO measurements using reconstruction techniques.

Dr Emma Ryan-Weber

CAASTRO Associate Investigator
Theme: Evolving

In 2012 Ryan-Weber continued her research in the evolving theme, working on high redshift galaxies and their surrounding gas. Two observing runs with the Keck Telescope saw the remaining data required for Gonzalo Diaz's PhD project successfully collected and the discovery of superluminous supernovae at redshifts of 2.05 and 3.90.

Associate Professor Chris Blake

CAASTRO Associate Investigator
Theme: Dark

Blake leads much of the CAASTRO Dark Theme activities at Swinburne. His research in 2012 involved finalising a series of published cosmological analyses of the WiggleZ Dark Energy Survey (cosmic expansion history, neutrino mass limits, turnover in power spectrum) together with new applications of the data (joint analyses with gravitational lensing, galaxy clusters, multiple-tracer analysis).

Dr Jun Koda

CAASTRO Postdoctoral Researcher
Theme: Dark

Koda's work is focussing in two main areas. Firstly he has completed a Fisher-matrix forecast study of future surveys of galaxy peculiar velocities (e.g. 6dFGSv, SkyMapper, WALLABY, TAIPAN), in order to investigate the optimal use of such datasets to constrain cosmological models in comparison to other cosmological probes such as redshift-space distortions. Secondly, he is using novel techniques ("Comoving Lagrangian Acceleration") to build a large ensemble of mock galaxy catalogues that CAASTRO will employ in more detailed studies of these galaxy surveys.

Mr Andrew Johnson

CAASTRO Postgraduate Student
Theme: Dark

Johnson commenced his PhD in August 2012. He is performing power-spectrum modelling of the 6-degree Field Galaxy Survey velocity (6dFGSv) sample, the current largest peculiar velocity dataset in existence, in order to test cosmological theories on the largest scales. He has developed a pipeline to perform these fits and tested his analysis techniques on mock catalogues with realistic observational errors.

Ms Sue Lester

CAASTRO Administrator

Lester joined the Swinburne Node in March 2012. She has a Graduate Certificate in Business – Executive Administration and commenced with Swinburne at the startup of its Lilydale campus as PA to the DVC. After ten years in this role, Lester then assisted the Director of Marketing, also at Swinburne, for three years.

Australian National University

CAASTRO AT THE AUSTRALIAN NATIONAL UNIVERSITY (ANU)

The research of the CAASTRO radio astronomers at ANU emphasises the development of novel instrumentation and observational techniques for the study of hydrogen gas and its relation to star formation and the evolution of galaxies. During the past year, the ANU team has focused on two areas: the quantification of neutral hydrogen (HI) associated with relatively nearby galaxies (and how it has changed over the second half of the age of the Universe) and the commissioning of the Murchison Widefield Array, which has been built to study HI in the intergalactic medium as the first generation of stars light up in the first galactic structures during the first billion years after the Big Bang.

The study of gas in relatively nearby galaxies at recent times has relied on observations with established observatories, including the Westerbork Synthesis Radio Telescope in the Netherlands and the Giant Metrewave Radio Telescope in India. The ANU group leads international collaborations that must include complementary optical observations to establish the relation between gas content and star formation histories.

The ANU's role in the MWA project has advanced from our early role in instrumentation design and testing to field commissioning and performance verification. A deep understanding of the telescope is necessary to achieve sensitivity to low surface brightness gas clouds, which must be observed in the presence of astronomical and terrestrial "foreground" radiation. An ANU speciality is the detection, characterisation and mitigation of radio frequency interference from earth based transmitters and spurious radiation emitters.

At the Australian National University, the CAASTRO node is headquartered in the library wing of the heritage listed Commonwealth Solar Observatory building at the hub of the Mount Stromlo Observatory. Since the bush fires of January 2003, the ANU has undertaken instrumentation projects relevant to the three main themes of CAASTRO in the observatory's new Advanced Instrumentation and Technology facility.

SkyMapper undertook regular observations in 2012 but continues to be hampered by the resolution of images due to shaking. Work still continues to address this issue, however SkyDice was successfully installed into the SkyMapper dome. SkyDice is a new system that will reference the calibration of photometric data that will be produced by the SkyMapper telescope and to achieve an overall photometric accuracy to a tenth of a per cent level - a brilliant initiative undertaken by Dr Nicolas Regnault and his colleagues from LPNHE laboratory in Paris that has the possibility to revolutionise astronomy.

The SkyMapper transient discovery pipeline is designed to search SkyMapper data quickly and efficiently for transient and variable objects, including type Ia supernovae for measurements of the Universe's expansion rate and of peculiar velocities (Dark Theme), other types of supernovae (Dynamic Theme), and rapid-response follow-up targets such as gamma-ray bursts and radio transients (Dynamic Theme). Since these transients often appear against a bright background from the host galaxy at optical wavelengths, the pipeline works by difference imaging, subtracting old SkyMapper images from ones taken more recently to remove light from galaxies and reveal underlying point sources.

The first prototype of the pipeline to work on SkyMapper images was completed in 2011. In 2012 this prototype was scaled up to ensure that a full night of SkyMapper data could be subtracted in less than 24 hours, an essential requirement for the supernova search; a separate workflow was added for quick reduction of rapid-response targets; and web browser views were added for job status monitoring and for review of candidates discovered by the pipeline. The size and symmetry of the SkyMapper PSF are currently still limited by vibrations in the telescope, but in 2013 either these vibrations will be fixed or software features will be added to the pipeline to improve its performance on asymmetric data, leading to the first independent transient discoveries from SkyMapper.

A new rapid data reduction pipeline for the WiFeS spectrograph on the ANU 2.3m telescope was developed in 2012 at ANU. It processes new data in less than one minute, enabling real-time classification of new astrophysical transients. The pipeline was used to classify a dozen new supernovae in 2012, including SN 2012fr in the nearby galaxy NGC 1365. SN 2012fr will become a new fundamental calibrator for measuring the Hubble constant, and was studied in great detail by the ANU supernova team.

CAASTRO ANU Team members

Professor Brian Schmidt

CAASTRO Chief Investigator, Dark Universe Theme Leader
Themes: Evolving, Dynamic, Dark

Schmidt continued to lead work on SkyMapper, including commissioning activities and software development. This work will finish in early 2013, and will be followed by regular operations and the beginning of both the Southern Sky Survey, and the SkyMapper Supernova Survey. Schmidt was awarded the 2011 Nobel Prize in physics, and in association with this award made innumerable media appearances both in Australia, and internationally. Schmidt completed the year with 18 international trips and over 35 public lectures.

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 the 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 2012 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 2013, he will continue his research on radio techniques, with emphasis on the characterisation and suppression of the effects of radio frequency interference

Ms Ragini Singh

CAASTRO Postgraduate Student
Theme: Evolving

Singh joined the CAASTRO Evolving theme as a PhD student member in 2012. She worked on detecting the Transverse Proximity Effect in a pair of quasars with a transverse separation of 100 kpc, combining observational data obtained using the MIKE spectrograph on the Magellan telescope with photoionisation modelling using MAPPINGS III. This close quasar pair is now being used to study the IGM metallicity at $z > 2.2$.

Dr Richard Scalzo

CAASTRO Associate Investigator
Theme: Dynamic

Scalzo's research focuses on observational studies of supernovae at optical wavelengths. He is particularly interested in Type Ia supernova progenitors and explosion physics. In 2012 he led development work on the SkyMapper transient discovery pipeline, which is now ready for normal operations (pending solution of technical problems with the telescope). He also developed a method to infer the mass ejected in a Type Ia supernova explosion from its bolometric light curve, placing strong constraints on progenitor scenarios. First results from the method, applied to superluminous Type Ia supernovae in which the ejected mass is likely to exceed the Chandrasekhar mass, have been published, and Scalzo looks forward to applying the method to large public photometric data sets of normal Type Ia supernovae in 2013.

Dr Philip Lah

CAASTRO Affiliate
Theme: Evolving

Lah holds a joint post-doctoral appointment that allows him to split his time between the Research School of Astronomy and Astrophysics at the ANU, where he is a CAASTRO member, and the National Centre for Radio Astrophysics in Pune, India. Lah's recent research following on from his PhD at ANU has focused on measuring the neutral gas content of galaxies as a function of time through observations of the 21cm line from galaxy populations over a range of redshifts. His research interests include multi-wavelength extragalactic astronomy, optical spectroscopy, radio astronomy in the 21cm line, data analysis techniques and data mining in large databases.

Mr Benjamin McKinley

CAASTRO PhD Student
Theme: Evolving

McKinley's main role as a CAATRO PhD student in the Evolving theme is to contribute to the science commissioning of the Murchison Widefield Array (MWA), a new radio telescope which is designed to search for the faint low frequency radio signal from the Epoch of Reioinisation (EoR). In 2012 McKinley published his first refereed journal article which presented observations of the Moon with the MWA 32 tile prototype and discussed the possibility of using the Moon as a calibration source for EoR detection. McKinley's other main focus in 2012 was studying the nearby radio galaxy Centaurus A at low frequencies and how foreground emission from our own galaxy affects the observations and analysis of this object.

Dr Patrick Tisserand

CAASTRO Postdoctoral Research Fellow
Theme: Dynamic

Tisserand worked on the commissioning of the SkyMapper telescope and the installation of the Skydice optical instrument inside the dome. This instrument will be used routinely as an external photometric calibration source. Tisserand has worked also on the search and study of intermediate mass white dwarfs merger product, called R Coronae Borealis stars. These supergiants can be used to better understand the higher-mass merger that can result in Type Ia supernovae.

Ms Sharon Rapoport

CAASTRO Student
Theme: Evolving

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 Sim's 3D radiative transfer code) to better understand the observational expectations from gamma-ray bursts associated with supernovae. In the next year Rapoport plans to create her own hydro model and to explore the model's parameters space to allow easier identification of newly observed GRB-SN, and use observational constraints to locate the possible parameters plane for such explosions.

Dr Stuart Sim

CAASTRO Associate Investigator
Themes: Dynamic, Dark

Sim's research focuses on the theory of supernova explosions. In 2012, he worked on developing new models for Type Ia supernovae, the events which are used as "standard candles" to map out the expansion history of the Universe. He also worked 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.

Dr Fang Yuan

CAASTRO Postdoctoral Researcher
Theme: Dynamic

Yuan is a member of the SkyMapper transient team, responsible for developing the data processing pipeline and coordinating gamma-ray burst (GRB) followups. She is interested in peculiar sub-luminous explosions, super-luminous supernovae and GRBs. In 2012, she continued her investigation into the origin of the faint "calcium-rich" supernovae through studies of their explosion sites and observations from new discoveries. In the coming years, she is looking forward to discovering and studying a diverse range of transients that will help us understand stellar evolution in different environments.

Mr Jonghwan Rhee

CAASTRO Postgraduate 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 2012 he carried out and began analysing observations with radio telescopes such as the WSRT and the GMRT, and optical spectroscopic observations with the Anglo-Australian and Multi-Mirror Telescopes. Analysis of one of the targets fields has been completed and it shows that there is HI gas evolution from $z=0$ to $z=0.2$. In 2013, he plans to submit the result to a journal, and complete his analysis of the remaining target fields and publish the results.

Dr André Offringa

CAASTRO Research Fellow
Theme: Dynamic, Evolving

Offringa started as a post-doctoral fellow in September 2012 and is performing research on algorithms for the data processing of the Murchison Widefield Array (MWA). The MWA radio telescope will generate huge data volumes, and processing these efficiently is an exciting challenge. Offringa's main science interests are the mitigation of radio-frequency interference (RFI) and the detection of faint redshifted HI signals from the Epoch of Reionisation: a yet unseen era in the lifetime of our Universe. He is also interested in efficient calibration and imaging of radio data.

Dr Michael Childress

CAASTRO Postdoctoral Researcher
Theme: Dark

Childress joined ANU at the start of 2012 after completing his PhD at Berkeley. In addition to submitting two papers from his thesis work on host galaxies of Type Ia supernovae, Childress has led development of a new fast data reduction pipeline for the WiFeS instrument, which will be used for rapid transient classification. He is continuing to use WiFeS for follow-up spectroscopy of nearby supernovae and integral field spectroscopy of supernova host galaxies.

Ms Rose Metcalfe

CAASTRO Administrator

Metcalfe is the CAASTRO Node Administrator at the Australian National University. She has been an employee of the ANU since 2008 and has worked in many different areas of the institution.

CAASTRO LINKAGES & COLLABORATIONS

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 reputations in international astronomy, with proven track records 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 Society. 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.

2012 saw the opening of the Australian Square Kilometre Array Pathfinder telescope and the shared awarding of the Square Kilometre Array to Australia and South Africa. Combined with the Murchison Widefield Array, SkyMapper, the Square Kilometre Array Molonglo Prototype and the Pawsey High Performance Computing Centre for SKA Science, Australia's large investments in wide-field technologies and in high-performance computing are enabling CAASTRO to create a world-leading research program.

Associate Investigators

Dr Chris Lidman (AAO)

Dr Lidman is an Associate Investigator in CAASTRO, and his role is in the Dark Universe Theme, where he will contribute to the follow-up of Type Ia supernovae discovered by SkyMapper. His expertise is in observational cosmology, Type Ia supernova, galaxy clusters, primordial galaxies, and exotic transient phenomena. Lidman is an expert in adaptive optics, near-IR imaging and optical spectroscopy. In addition, Lidman has commissioned several instruments at two major international observatories.

Dr Tamara Davis (UQ)

Dr Davis is an Associate Investigator with CAASTRO, and her expertise is in the interpretation of cosmological observations in terms of their implications for fundamental physics. In particular she focuses on determining the nature of Dark Energy and Dark Matter, and the validity of the "Lambda-Cold Dark Matter" paradigm, using supernovae and large scale structure. Davis is part of the Dark Universe theme, under which she focuses on the theoretical interpretation of the velocity field and density field measurements made by SkyMapper, ASKAP and the Anglo-Australian Telescope. She contributes the theoretical background necessary to perform the velocity field measurements, and will adapt the theoretical predictions to the specific observational parameters of the surveys performed within CAASTRO.

Partner Investigators

Australian Astronomical Observatory

Professor Matthew Colless

As Director of the Australian Astronomical Observatory, Professor Colless 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) and of the UK Schmidt Telescope (UKST). He 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, and 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. To do this he will combine 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 ~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.

Associate Professor Andrew Hopkins

Associate Professor Hopkins is coordinating the contributions of the Australian Astronomical Observatory to CAASTRO, together with AAO Director Professor Matthew Colless.

Hopkins manages and coordinates CAASTRO-supported student and postdoctoral researchers who observe with and utilise data from the Anglo-Australian Telescope and the UK Schmidt 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 has been heavily involved in the SKA. His primary research interests are in the fields of quasars, active galaxies and cosmology. 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 Robert Braun

Dr Braun is Chief Scientist for CSIRO Astronomy and Space Science. Braun's scientific contributions to CAASTRO are under the Evolving Universe research theme, through his participation in the WALLABY and FLASH surveys using ASKAP. For WALLABY, Braun's area of focus will be to examine varying galaxy populations in different environments, which he will use to test galaxy evolution theories. FLASH will undertake an untargeted all-sky survey of HI absorption at intermediate redshifts (z = 0.5 – 1). Braun's specific interest is to measure the dependence with redshift of the neutral gas density of the Universe, and to discriminate between models of galaxy assembly in this redshift range.

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 Discovery and (formerly Large) 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.

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, especially valuable for the Skymapper survey's search for high redshift quasars. 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.

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. Pain is also overseeing an independent transient pipeline constructed for SkyMapper that will work in tandem with an Australian-based pipeline. These two independent pipelines are required to achieve the precision required from the next generation of supernova surveys.

University of Toronto, Canada

Associate Professor Ue-Li Pen

Associate 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

Professor Roger Davies

Professor Roger Davies is Head of Astrophysics at Oxford University. Within CAASTRO, Davies's contribution will be 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 Linday 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 2012 alone, some 4 million CPU hours were utilised.

CAASTRO COLLABORATIONS

CAASTRO staff have been involved in a number of collaborations with institutions both in Australia and internationally during the course of 2012, including the following:

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.

WiggleZ

Institutions: Swinburne University of Technology, University of Toronto (Canada), Australian Astronomical Observatory, 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, Clayton, VIC 3800, Australia), AU(Centre for Astrophysics and Supercomputing, 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.

Epoch of Re-ionisation 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 dataset with the MWA 128T array to either detect or set limits on the detection of the HI signals from the Epoch of reionisation. During 2012, the hardware for the 128T array was deployed in the field, and substantial progress was made in developing the data processing pipelines for the vast amounts of data that the telescope will produce.

Large Synoptic Survey Telescope

Institutions: The Large Synoptic Survey Telescope (comprising more than 30 member organisations) and CAASTRO

CAASTRO and The Large Synoptics 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.

PanSTARRS

Institutions: The University of Hawaii, Monash University, University of Queensland and CAASTRO

CAASTRO was successful in 2012 in obtaining LIEF funding to join PanSTARRS, a planned series of four 1.8-metre telescopes in Hawaii (the first has been operational since 2010 and first light is planned for the second telescope in 2014) to rapidly survey the sky at optical wavelengths.

SkyMapper Supernova Search

Insitutions: HEP - Paris VI: ANU -RSAA

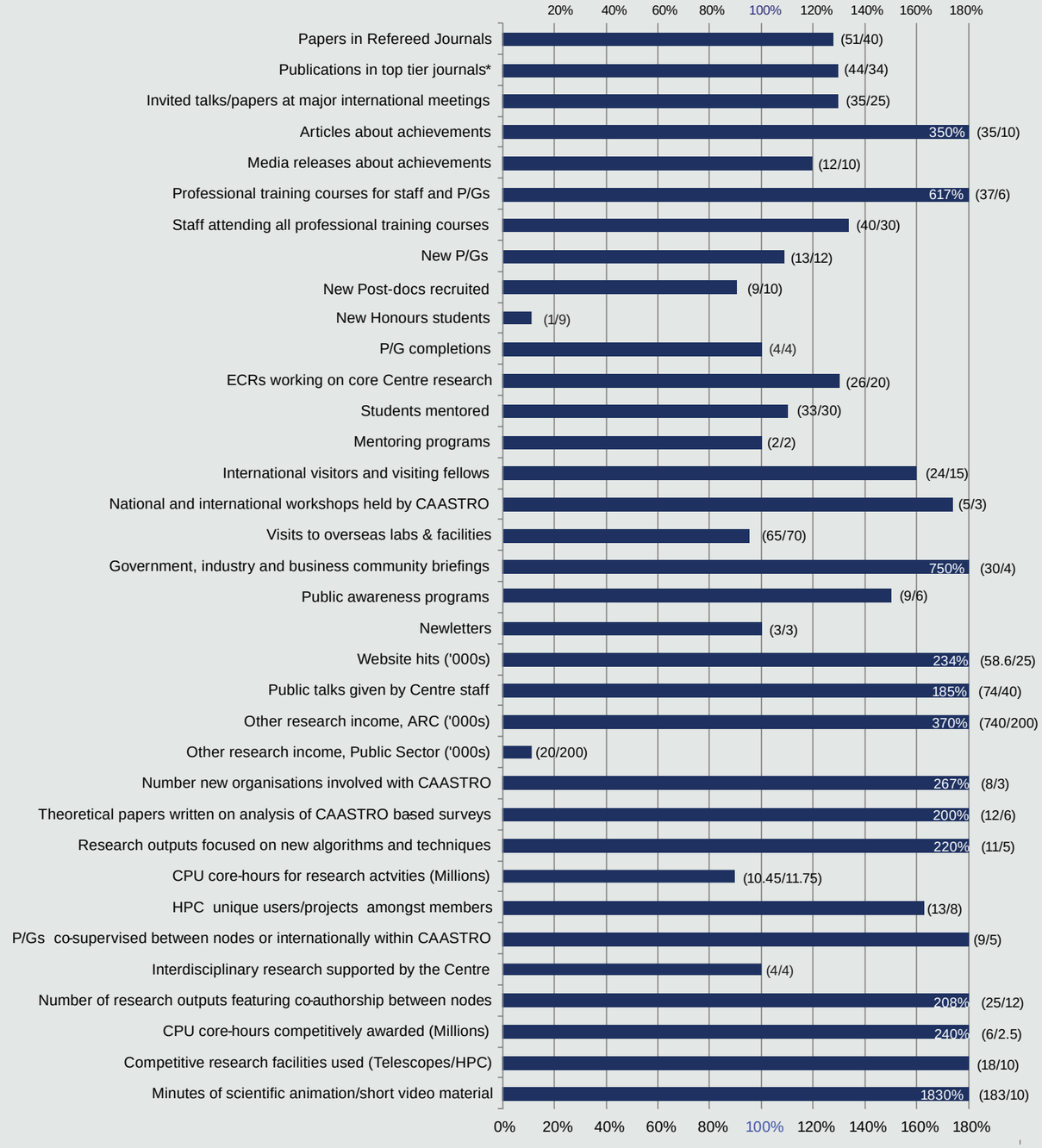
SkyMapper is a 5.7 deg^2 imager mounted on a dedicated 1.3 m telescope installed at the Siding Spring Observatory (NSW, Australia). Among the core goals of SkyMapper is a large nearby supernovae survey (S5). S5 aims at producing a nearby SN Ia sample comparable in quality to those gathered by Supernova Legacy Survey and Sloan Digital Sky Survey. As part of the collaboration, The SkyDice (SkyMapper Direct Illumination Calibration Experiment) system is a dedicated photometric calibration device that has been installed in the SkyMapper enclosure on June 2012. This program aims to provide the photometric datasets that minimize 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 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, NASA Jet Propulsion Laboratory, Max Planck Institut für Radioastronomie.

CAASTRO staff have been involved in the High Time Resolution Universe survey collaboration in 2012. This survey searches the sky using the Parkes Multibeam Receiver and searches for phenomena with a time resolution of just 64 microseconds. 2012 has been a very successful year for the collaboration discovering some new impulsive bursts of radiation from what appear to be cosmological distances.

KPI DASHBOARD



* 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 2012

2012 INCOME		2013 ESTIMATED INCOME	
ARC Income	$2,800,000	ARC Income	$3,100,000
ARC Indexation	$153,527	ARC Indexation	$169,973
Node Contributions*	$1,039,569	Node Contributions	$1,012,229
		ARC LIEF Grant	$740,000
		G08-DAAD Joint Research Co-operation Scheme	$10,000
Other**	$13,685	Other	$-
Total Income	**$4,006,781**	**Total Estimated Income**	**$5,032,202**
Carry Forward	$2,930,552	Carry Forward (ARC & Node Contributions)	$2,834,054
		Carry Forward (Other income)	$133,931
Total Funds Available	**$6,937,333**	**Total Estimated Funds Available**	**$8,000,187**

*Includes payment by ANU for 2011, $69,539

**Other income includes interest from NSW SLF Grants and Scholarship Contribution

2012 EXPENDITURE		2013 ESTIMATED EXPENDITURE	
Salaries	$2,807,859	Salaries	$3,356,602
Travel, Accommodation and Conference	$503,587	Travel, Accommodation and Conference	$617,000
Marketing & Outreach	$139,732	Marketing & Outreach	$125,000
Operations & Maintenance	$81,706	Operations & Maintenance	$30,400
Equipment	$145,790	Equipment	$22,446
PhD Support	$101,763	PhD Suppport	$180,000
Research materials/ Experiments	$188,911	Research materials/Experiments	$-
		Other - Equipment (ARC LIEF Grant)	$740,000
		Other - Travel (G08-DAAD Joint Research Co-operation Scheme)	$10,000
Total Expenditure	**$3,969,348**	**Total Estimated Expenditure**	**$5,081,448**
Balance	**$2,967,985**	**Estimated balance**	**$2,918,739**

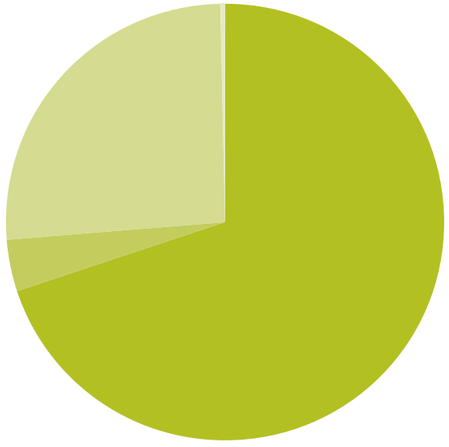
GRANTS WON

ARC LIEF Grant	G08-DAAD Joint Research Co-operation Scheme
Project title: Mapping the Universe with the Panoramic Survey Telescope and Rapid Response System	**Grant title**: Studying the distant universe through clustering of Lyman-alpha emitting galaxies
LE130100104	**Value:** $20,000 over 2 years (2013 & 2014)
Value: $740,000 over 1 year (2013)	**Sponsor:** The University of Melbourne
Chief Investigator: Bryan Gaensler	**Chief Investigator:** Stuart Wyithe

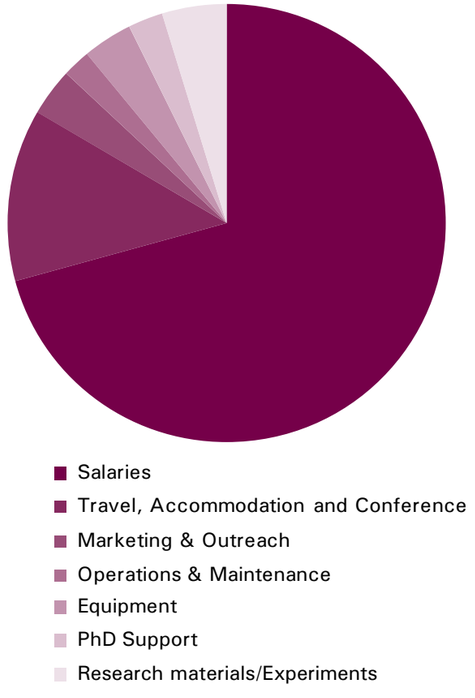
CAASTRO IN-KIND REPORT JANUARY - DECEMBER 2012

University of Sydney	$479,995
University of Western Australia	$174,225
University of Melbourne	$769,690
Swinburne University of Technology	$464,082
Australian National University	$784,596
Curtin University of Technology	$367,992
CSIRO	$327,710
Anglo-Australian Observatory	$766,521
Max Planck Institute for Radio Astronomy	$146,695
California Institute of Technology	$134,673
The University of Oxford	$51,170
Durham University	$185,894
Max-Planck Institute for Astrophysics	$74,737
The University of Arizona	$60,000
The University of Toronto	$41,300
Laboratoire de Physique Nucleaire et de Hautes Energies	$186,000
National Computational Infrastructure	$1,000,000
Raman Research Institute	$200,000
Other in-kind income (University of Queensland)	$12,664
Total In-Kind Contributions	**$6,227,943**

2012 INCOME



2012 EXPENDITURE



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)

Chief Investigators

8. Frank Briggs
9. Warrick Couch
10. Scott Croom
11. Jeremy Mould
12. Elaine Sadler
13. Rachel Webster

Partner Investigators

14. Lindsay Botten
15. Brian Boyle
16. Robert Braun
17. Matthew Colless
18. Roger Davies
19. Xiaohui Fan
20. Carlos Frenk
21. Andrew Hopkins
22. Guinevere Kauffmann
23. Michael Kramer
24. Shri Kulkarni
25. Ray Norris
26. Reynald Pain
27. Ue-Li Pen


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28. Ravi Subrahmanyan

Associate Investigators

29. Ramesh Bhat
30. Chris Blake
31. Jamie Bolton
32. Tamara Davis
33. Chris Lidman
34. JP Macquart
35. Martin Meyer
36. Tara Murphy
37. Stephen Ord
38. Chris Power
39. Emma Ryan-Weber
40. Richard Scalzo
41. Stuart Sim
42. Randall Wayth


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CAASTRO Research Staff

43. Martin Bell
44. Julia Bryant
45. Michael Childress
46. Shin Kee Chung
47. Stephen Curran
48. Andrew Jameson
49. Akila Jeeson-Daniel
50. Eyal Kazin
51. Jun Koda
52. David Lagattuta
53. Emil Lenc
54. Greg Madsen
55. Daniel Mitchell
56. André Offringa
57. Se-Heon Oh

58. Pietro Procopio
59. Marcin Sokolowski
60. Chris Springob
61. Edoardo Tescari
62. Patrick Tisserand
63. Steven Tremblay
64. Cathryn Trott
65. Fang Yuan

CAASTRO Professional Staff

66. Jay Banyer (Software Engineer, U Sydney)
67. Kim Dorrell (Executive Officer, U. Melbourne)
68. Angela Dunleavy (Administrative Coordinator, Curtin U)
69. Wiebke Ebeling (Education & Outreach Coordinator)
70. Debra Gooley (Finance Officer)
71. Ruth Jeffries (Events & Communication Officer)
72. Rachel Kennedy (Administrative Assistant, Curtin U)
73. Katie Lau (Administrative Officer, UWA)
74. Sue Lester (Administration Officer, Swinburne)
75. Rose Metcalfe (Administrator, ANU)
76. Roselina Stone (Administrative Assistant, Curtin U)
77. Denise Sturgess (Administration Officer, ANU)
78. Michelle Sullivan (Executive Assistant to Director)
79. Darshan Thakkar (Digital Engineer)

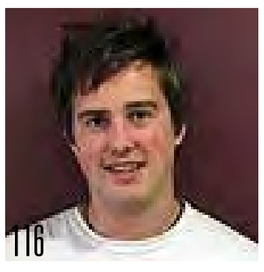
CAASTRO Affiliates

80. James Allen
81. James Allison
82. Keith Bannister
83. Davide Burlon
84. Duncan Campbell-Wilson
85. Alan Duffy
86. Jamie Farnes
87. Sean Farrell

88. Karl Glazebrook
89. Anne Green
90. Paul Hancock
91. Hansik Kim
92. Iraklis Konstantopoloulos
93. Philip Lah
94. Katie Mack
95. Shane O'Sullivan
96. Bart Pindor
97. Nicholas Scott
98. Willem van Straten

CAASTRO Students

99. Ben Barsdell
100. Loren Bruns, Jr.
101. Catherine De Burgh-Day
102. Bradley Greig

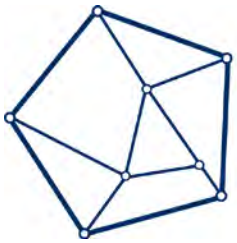


103. Tao Hong
104. Andrew Johnson
105. Antonios Katsianis
106. Lina Levin
107. Kitty Lo
108. Christina Magoulas
109. Ben McKinley
110. Mehran Mossammaparast
111. Steven Murray
112. Samuel Oronsaye
113. Sinem Ozbilgen
114. Emily Petroff
115. Sharon Rapoport
116. Glen Rees
117. Sarah Reeves

118.Nastaran Rezaee
119.Jonghwan Rhee
120.Jennifer Riding
121.Morag Scrimgeour
122.Ragini Singh
123.Syed Uddin

Not pictured

124.Tina Sallis
(Finance Manager,
Curtin U.)
125.Syed Faisal-Ur-Rahman



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THE UNIVERSITY OF SYDNEY

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SWINBURNE UNIVERSITY OF TECHNOLOGY

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Curtin University

International Centre for Radio Astronomy Research

Australian Government
Australian Research Council

NSW GOVERNMENT Trade & Investment