CAASTRO

ARC CENTRE OF EXCELLENCE
FOR ALL-SKY ASTROPHYSICS

ONE

ANNUAL REPORT 2011

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

When Bryan Gaensler invited me to be the prospective Chair of the CAASTRO advisory board prior to the submission of the ARC application, it was too soon for me to envisage the strength of the Centre. However, I knew Bryan's passion for excellence and big thinking, so it was my pleasure to accept. In the short time that CAASTRO has been operating, it is clear that it consists of an extraordinary assembly of scientists, each of whom is working to increase our understanding of the fundamental nature of the universe.

The staff and students in CAASTRO are already enthusiastically developing innovative new ways to analyse the masses of data being collected by the current and emerging generation of super telescopes. This is a collaborative effort that spans nations and institutions, with much of the work of CAASTRO involving existing institutional allegiances and active partnerships.

In addition to the inspiring science, under the leadership of Bryan and his fellow members of the executive team CAASTRO actively pursues a broader community responsibility. Significant time and effort are put aside for public lectures, delivering in-school and remote school classes, and authoring articles for the lay community. In this pursuit CAASTRO goes beyond the written and spoken word to include magnificent animations that leave lasting impressions with the audience. An exquisite example of this is the animation illustrating the diamond planet discovered by a team led by Matthew Bailes, CAASTRO executive member and professor at Swinburne University of Technology.

On a more personal front, I am pleased to report that I am delighted with the calibre of the members of the advisory board, with their skills spanning the spectrum of science communication, strategy and scientific know-how. I take this opportunity to formally thank my fellow advisory board members for volunteering their time for meetings and discussions. One of our key meetings was the face-to-face gathering we had in Perth last year, during which we not only met with the executive but also many staff and students. The highlight of this meeting was a series of short, sharp and fascinating presentations by CAASTRO students and staff on their astronomical observations and analyses. These presentations confirmed for us the depth of the intellectual strength of the organisation, at all times accompanied by good spirits, optimism and enthusiasm.

Our official launch was in September 2011 at Sydney Observatory, creatively illuminated for the occasion, and with its own historical beauty that paid testament to the magnificence of the CAASTRO undertaking. Governor Marie Bashir was inspired by the spirit of the occasion and gave a stirring launch address.

Overall, the first year has been a very promising start and it is my pleasure to commend this annual report to you.

Alan Finkel AM PhD FTSE
Chair, CAASTRO Advisory Board

VISION & MISSION STATEMENT

The CAASTRO Vision

CAASTRO will be the 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 will carry out key science with 21st century telescopes, culminating in the Square Kilometre Array. 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 SKA 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 the last few 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 will deliver 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 $29 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

THE CALIBRE OF THE CAASTRO TEAM IS REFLECTED IN THE EXTERNAL RECOGNITION THAT THEY HAVE RECEIVED THIS YEAR

CAASTRO's first year has been one of rapid growth, exciting accomplishments and substantial progress toward all our goals. One of the main motivations for establishing CAASTRO was to bring talented astronomers with diverse expertise into a focused collaborative environment. An especially pleasing outcome of 2011 has been to indeed see a variety of our researchers working together in new and innovative ways as we set out to solve some of the key problems of 21st century astrophysics.

In CAASTRO's Dynamic Universe theme, the unquestioned highlight of the year was the paper published in *Science* by Matthew Bailes and a large international team, on the discovery of a dense planetary-massed object orbiting a millisecond pulsar. This "diamond planet" is not just an important missing link in stellar evolution, but proved to be a worldwide sensation: our video animation explaining the discovery picked up more than 500,000 hits on YouTube in its first 24 hours.

Within our program on the Evolving Universe, we have been able to quickly assemble a critical mass of observers and theorists, who have now begun working together to search for the faint radio signals from the Epoch of Reionisation. A range of activities has commenced in this area, including development of algorithms for foreground subtraction, new supercomputing simulations of reionisation, and some early science from our marquee reionisation experiment, the Murchison Widefield Array.

CAASTRO has also taken on board an exciting new project in the Evolving Universe theme led by Scott Croom, in which we aim to perform spatially resolved spectroscopy of tens of thousands of galaxies using the unique capabilities of the Sydney-AAO Multi-object Integral field spectrograph (SAMI).

For the Dark Universe research theme, CAASTRO again has been successful in recruiting some talented young postdocs and students from around the world. As part of this effort, Chris Blake, Tamara Davis, Warrick Couch and their team are working on a whole range of new cosmological constraints that can be extracted from the recently published WiggleZ data set. Elsewhere, CAASTRO student Bradley Greig has developed a new approach to simulating the high-redshift Universe with graphics processing units (GPUs), through which a single laptop can reproduce in a day what could only previously be done on large supercomputers.

As I've already alluded, the strength of CAASTRO is in its people. I find it astonishing that at the end of our first year, we already have over 90 members of our Centre, including 20 research staff and more than a dozen PhD students. Most of the projects planned in collaboration with our international partners are now underway, and I'm also pleased to report the addition of the Raman Research Institute as a new Partner Organisation, with whom we will be working on a variety of reionisation experiments. We are currently in the final stages of discussion with several other prospective new partners, whom I look forward to welcoming in 2012. Sadly, we have also lost a valued collaborator, with the unexpected and untimely passing of CAASTRO partner investigator Prof Steve Rawlings. Steve was an innovative researcher, a champion of the Square Kilometre Array and a valued mentor and friend – we are still coming to terms with his absence. An obituary for Steve appears at the end of this report.

The calibre of the CAASTRO team is reflected in the external recognition that they have received this year: highlights included an Australian Laureate Fellowship and the 2011 Malcolm McIntosh Prize to Stuart Wyithe; the 2011 Pawsey Medal to Bryan Gaensler; ARC Future Fellowships to Scott Croom, Tamara Davis and Chris Blake; the 2011 AIP Women in Physics Lectureship and the 2011 Queensland Tall Poppy Award to Tamara Davis; the 2011 Gruber Prize in Cosmology to Carlos Frenk; and of course the 2011 Nobel Prize in Physics to Brian Schmidt. I hope this does not set expectations too high for 2012!

Despite the relatively short lead-up time, CAASTRO has already convened or sponsored several events to promote our activities and to stimulate work in our key research areas. The highlight was the official launch of CAASTRO, by Her Excellency Professor Marie Bashir, Governor of New South Wales, in September 2011 at Sydney Observatory. CAASTRO staff and students mingled with international guests, ARC and university representatives, members of the diplomatic corps, and even an astronaut, as we embarked on our journey and highlighted our plans for the future.

On the scientific front, we co-sponsored no less than three international meetings in June 2011: conferences on "Telescopes for 21cm Cosmology" (Canada), "Gas in Galaxies" (Germany) and "Planning for Cosmology" (Gold Coast). CAASTRO was also a sponsor of the inaugural "Women in Astronomy" workshop, held in Sydney in May 2011. Our activities for the year culminated in November 2011 in the small town of Bungendore, where more than 60 members of our team participated in our initial annual CAASTRO retreat. This was the first time that many of us met in person (and the first time that the entire CAASTRO executive had been physically together!) – the clear consensus coming out of the retreat was that CAASTRO was equipped with unique capabilities, and was already doing things that no one else can do.

Our education and outreach program is in its early stages but continues to build momentum. We have been fortunate to secure the talents of an especially dedicated and creative outreach officer in Wiebke Ebeling. Wiebke has developed a web page for CAASTRO full of news and timely information, continuously promotes all our activities across Facebook, Twitter and YouTube, and is working with the individual CAASTRO nodes on targeted programs of astronomy festivals, video-conferencing into classrooms and public lectures.

CAASTRO has been the beneficiary of an engaged and proactive Advisory Board, marked by especially energetic leadership from Dr Alan Finkel. The CAASTRO Advisory Board met three times in 2011, each time dispensing frank advice, highlighting areas of our activities to which we need to pay more attention, and offering us access to their own resources and networks.

As the complexity of our endeavour grows throughout 2012, I look forward to drawing on the broad experience of our Advisory Board to help guide our way.

I'd like to highlight the many people and organisations who have taken up the CAASTRO vision and who have so quickly helped convert a grant proposal into a vibrant, functional Centre. Foremost has been the generous funding provided the Australian Research Council, by the NSW Government and by the member organisations of CAASTRO. In all our activities, we are cognisant of the responsibilities that come with these funds, and have worked hard to make sure that every aspect of CAASTRO's expenditures are directly aimed at meeting our overall goals. I also thank the organisations that have made substantial in-kind contributions to our program, most notably CSIRO, AAO and NCI. It is pleasing to see that our work with these agencies is not proceeding merely as client and customer, but as genuine research partnerships between two groups with complementary resources and skill sets.

In establishing CAASTRO, we have aimed to place the best people possible into key roles, and the results are already showing in the quality and professionalism of all our activities. Our indefatigable Chief Operating Officer, Kate Gunn, has quickly become the heart and soul of CAASTRO, and has repeatedly shown great skill at gently steering excited scientists in the right direction. I would also particularly like to highlight the work of our Events Coordinator, Susan Parker, who not only put together a stunning CAASTRO launch, but just months later was able to repeat the effort by coordinating a highly stimulating and enjoyable annual retreat. Finally, I offer my deep appreciation to the CAASTRO Executive team, whose vast supply of energy, patience, scientific muscle and common sense has produced a respectful, collegial and stimulating Centre in which it is a thrill to participate.

Prof Bryan Gaensler
CAASTRO Director

RESEARCH PROGRAMS

An elevated view of CSIRO's new ASKAP antennas at the Murchison Radio-astronomy Observatory, October 2010. *Ant Schinckel, CSIRO*

THE EVOLVING UNIVERSE

Theme Leader: Professor Stuart Wyithe | University of Melbourne

Two of the key questions in our understanding of the Universe are how gas, stars and galaxies have evolved over cosmic time (the time since the Big Bang), and when in the Universe's time line did the first galaxies form? CAASTRO's Evolving Universe theme is centred on providing key new insights into these problems.

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. Our understanding of the history of the Universe has made considerable progress over the decades. The early Universe, after the Big Bang of 13.7 billion years ago and the initial opaqueness of glowing plasma of ionised hydrogen, was smooth and filled with neutral hydrogen as the temperature cooled and allowed the ionised hydrogen to recombined with electrons. By contrast, today's Universe is inhomogeneous and the hydrogen is mostly ionised again. However, the intervening reionisation process is yet to be observed – and remains the last major phase of the Universe's evolution since the Big Bang to be studied or fully understood.

The CAASTRO team is working on measuring the stellar and neutral hydrogen content of 500,000 galaxies spanning the last eight billion years, thus allowing us to discriminate between competing theories of galaxy formation. Astronomers are interested in neutral hydrogen as it is a key fuel for star formation and also a tracer of both interstellar material within galaxies and the motions of galaxies. At the same time, astronomers are interested in the structure and properties of the stellar populations that form. Only by connecting the life-cycles of stars and gas will we understand how galaxies form and evolve.

Stellar Population Trends

CAASTRO PhD student Christina Magoulas (University of Melbourne) and investigators Professor Matthew Colless (AAO) and Professor Jeremy Mould (Swinburne University of Technology), in collaboration with astronomers in Australia and overseas, have published an analysis of stellar population parameters for 7132 galaxies in the 6dFGS Fundamental Plane (FP) sample. In contrast to previous work, the team found that stellar population trends not just with velocity dispersion and FP residual, but with radius and surface brightness as well.

The team's ultimate aim is to derive distances and peculiar velocities for these galaxies, which will then be used to characterise the local galaxy field and improve cosmological models. By accounting for stellar population variations in the FP, the team is hoping to improve the FP relation's use as a redshift independent distance indicator.

The most remarkable finding is that the stellar population parameters vary through and across the plane, but show no variation at all along the plane, roughly corresponding to the parameter `luminosity density'. A galaxy's position along this vector is closely tied to its merger history, such that early-type galaxies with lower luminosity density are more likely to have undergone major mergers. This conclusion is reinforced by an examination of simulations, which show clear trends of merger history with this luminosity density.

Their paper has been accepted for publication in *Monthly Notices of the Royal Astronomical Society*.

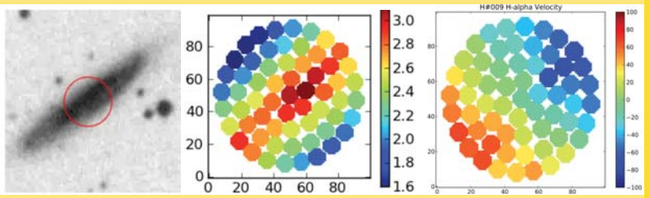
Reliability of Source-finding Algorithms

CAASTRO investigators Andrew Hopkins (Australian Astronomical Observatory), Ray Norris (CSIRO) and Tara Murphy (University of Sydney) have published an initial study of the source-detection algorithms SExtractor, Selavy (Duchamp) and SFIND.

The process of determining the number and characteristics of sources in astronomical images is so fundamental to a large range of astronomical problems, yet no standard procedure has ever been defined that has well-understood properties with a high degree of statistical rigour on completeness and reliability. The Evolutionary Map of the Universe (EMU) survey with ASKAP, a continuum survey of the Southern Hemisphere up to declination $+30^{o}$ that is expected to detect around 70 million galaxies, aims to utilise an automated source identification and measurement approach that is demonstrably optimal, to maximise the reliability, utility and robustness of the resulting radio source catalogues. This is a key requirement to handle the amount of data that will be collected by ASKAP.

A key stage in source extraction methods is the background estimation (background level and noise level) and the choice of a threshold high enough to reject false sources, yet not so high that the catalogues are significantly incomplete. The team found, using a set of ASKAP simulated data that, for parameters which give similar completeness, the false-discovery rate method employed by SFIND results in a more reliable catalogue compared to the peak threshold methods of SExtractor and Selavy.

Their results have been accepted to appear in *Publications of the Astronomical Society of Australia*.



SAMI IN ACTION - A spiral galaxy's dynamics revealed through hexabundle imaging and spectroscopy. The spiral galaxy in the left panel was one of the galaxies observed with SAMI to give the image in the central panel. Redder pixels indicate more intense continuum light along the edge-on galaxy disk. SAMI hexabundles give a spectrum in every fibre core, or spaxal, from which the velocities of stars and gas can be measured across the galaxy. From these velocities, a rotation image was constructed (right panel) in which the bluer parts of the galaxy are rotating towards us and the redder parts away from us, showing that the gas in this galaxy is rotating around a disk.

CREDIT: Croom et al

Dissecting galaxy evolution with integral field spectroscopy

2011 saw the Sydney-AAO Multi-object Integral field spectrograph (SAMI) incorporated as a new project within the CAASTRO Evolving Universe theme. SAMI is a prototype wide-field system that was commissioned at the Anglo-Australian Telescope in 2011. SAMI allows 13 imaging fibre bundles ("hexabundles"), each comprising 61 multimode fibres, to be deployed over a 1-degree field.

CAASTRO's Scott Croom (University of Sydney), in a team also including Julia Bryant (University of Sydney), Matthew Colless, Andrew Hopkins (both Australian Astronomical Observatory), has published the first spectroscopic results obtained with SAMI for a sample of galaxies at redshifts around 0.05, in a paper accepted for publication in *Monthly Notices of the Royal Astronomical Society*.

SAMI allows spatially resolved spectroscopy to be performed on a huge sample of galaxies over a wide area, allowing us to distinguish their individual structural components. For the SAMI commissioning run, a wide cross-section of galaxy spectral types were selected from the 6dF Galaxy Survey to evaluate the instrument's potential performance for a range of scientific applications. These commissioning results demonstrate the exciting scientific potential of multiplexed integral field spectroscopy as the next step in galaxy surveys. SAMI will next undertake a very large survey of up to 10,000 galaxies, allowing us understand the physical processes (such as feedback and environmental effects) which drive galaxy evolution in the local Universe, a key goal within CAASTRO's Evolving Universe theme.

For more on SAMI, see the case study on pp20-21

Recovering the Signature of Cosmic Hydrogen Reionisation

The measurement of redshifted 21-cm emission from neutral hydrogen promises to be the most effective method for studying the reionisation history of hydrogen and, indirectly, the first galaxies. These studies will be limited not by raw sensitivity to the signal, but rather by bright foreground radiation from Galactic and extragalactic radio sources (typically brighter by 4-5 orders of magnitude) and the Galactic continuum.

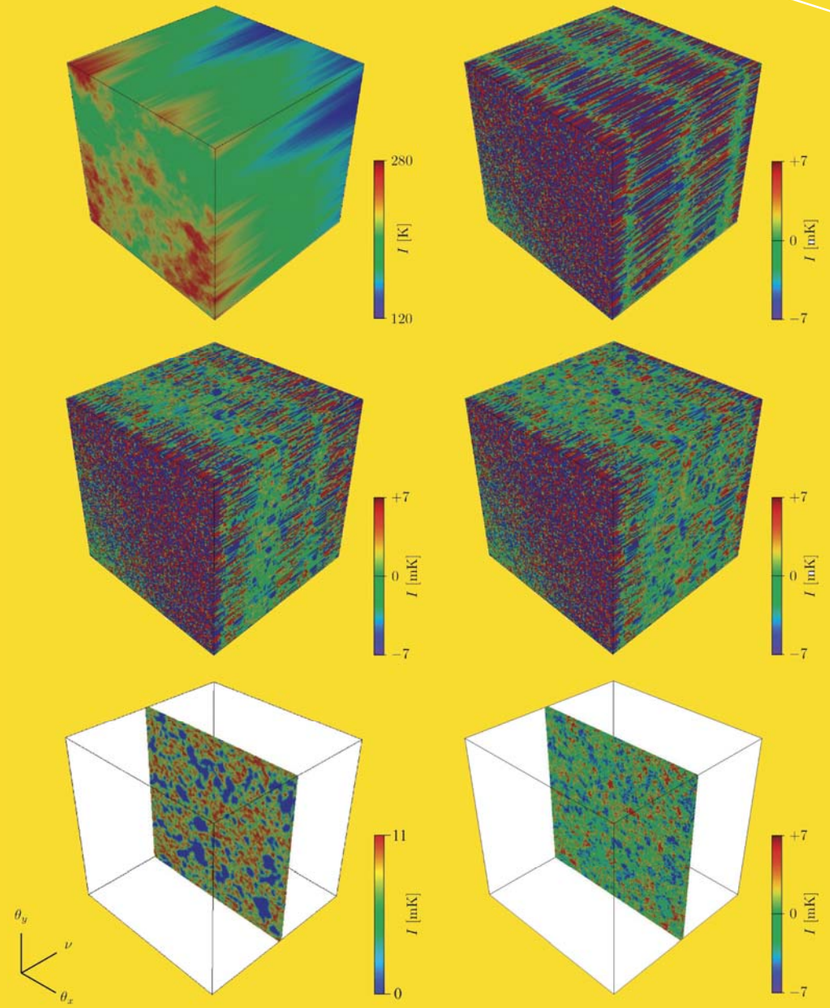
An additional challenge to detection of reionisation is that leakage due to gain errors and non-ideal feeds (collectively known as instrumental polarisation leakage) conspires to further contaminate low-frequency radio observations. This leakage leads to a portion of the complex linear polarisation signal finding its way into the non-polarised component of observations (known as Stokes I), and inhibits the detection of the non-polarised cosmological signal from the epoch of reionisation.

Working with PhD student Paul Geil (University of Melbourne), CAASTRO investigators Professor Bryan Gaensler (University of Sydney) and Professor Stuart Wyithe (University of Melbourne) have shown that it is possible to recover in an accurate manner the signature of reionisation late in the epoch of reionisation (redshifts around 7) within the sensitivity limits of the Murchison Widefield Array.

To achieve this, the team applied the rotation measure synthesis technique (which utilises the Fourier relationship between the complex linear polarisation signal and the Faraday dispersion function) to the Stokes I component of a synthetic data cube containing Galactic foreground emission, the effect of instrumental polarisation leakage and redshifted 21-cm emission by neutral hydrogen from the epoch of reionisation. This produces an effective Stokes I Faraday dispersion function for each line of sight, from which instrumental polarisation leakage can be fitted and subtracted.

Their work was published in *Monthly Notices of the Royal Astronomical Society*.

PERFORM



RECOVERING REIONISATION: A simulation of the sky over the frequency range 160-190 MHz, and the steps needed to recover the reionisation signal. The top left panel shows the raw data, which are totally dominated by bright Galactic synchrotron emission. At upper right, the continuum foreground signal has been removed, but its polarisation leakage still dominates the image. The middle two panels show successive stages of removing the polarisation leakage via rotation measure synthesis. In the bottom row, the original input reionisation signal (lower left) is compared to the signal recovered from the simulated data (lower right).

CREDIT: Geil et al.

THE DYNAMIC UNIVERSE

Theme Leader: Professor Matthew Bailes | Swinburne University of Technology

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 over the seven years of the Centre is 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 Australian Square Kilometre Array Pathfinder (ASKAP), the Murchison Widefield Array (MWA) 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, and over a wider range of time scales than ever before. CAASTRO staff members are developing the tools and techniques to maximise the scientific return from these new telescopes whilst continuing to use existing facilities in Australia and elsewhere.

To do this though, and to manage the enormous amounts of data generated by these surveys, CAASTRO is involved in implementing new software algorithms and pipelines that can identify variables and transients in an efficient manner. All this information will then be processed using the supercomputers at the Pawsey HPC Centre in Perth and at the National Computational Infrastructure in Canberra. By developing these innovative techniques to detect weak signals in large data sets, CAASTRO will also position Australia to capitalise on the powerful capabilities that will be presented by the forthcoming Square Kilometre Array.

Detection Rates for Transients with New Radio Arrays

As we look to the new systems of radio arrays coming online that CAASTRO is working with (such as ASKAP, the MWA and ultimately the Square Kilometre Array), CAASTRO's Dr Jean-Pierre Macquart (Curtin University) has explored the optimal strategies for the detection of fast transient radio emissions.

Crucial to the detection of such rare events is the field of view available. The Parkes radiotelescope utilises multibeam technology, the MWA uses aperture array technology which has a very large field of view, and ASKAP employs focal plane aperture array technology to achieve a field of view of 30 square degrees. The distribution of the interferometer elements and processing limitations leads to a tradeoff between the large field of views and the sensitivity of the surveys.

Macquart's work, published in *The Astrophysical Journal*, investigated the underlying properties of a transient's population to its expected detection rate. For events that are bright enough to be detected at extragalactic distances, the question is one of sensitivity-limitation, while Milky Way surveys have to consider that the volume of space is finite (the Galaxy's boundaries). Distance also plays an important role (is the detection rate dominated by near or far objects?) since this determines how much scattering the radiation from the transient event is subject to.

Macquart has examined survey potentials depending on whether the telescope elements are in a collimated survey mode (i.e. every element is pointed in the same direction) or in a "fly's eye" mode (i.e. each telescope is pointed in a different direction). He has found that when the expected transient event rate is constant over the entire field of view of the survey telescope, more events can be found using the "fly's eye" approach, while if there are large expected variations, a collimated survey approach should be adopted on the high event rate region.

A Carbon White Dwarf

CAASTRO team members are playing a leading role in the High Time Resolution Universe Legacy Survey, an ambitious project that is utilising the Parkes radio telescope and the Swinburne University Supercomputer to search the entire southern sky for fast transient radio signals, with a total proposed observing time of 6000 hours.

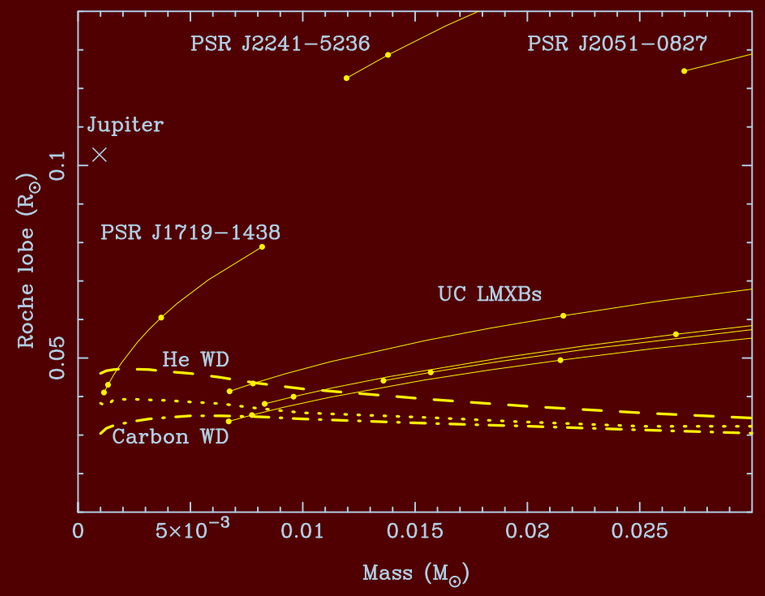
Lead by Professor Matthew Bailes, the survey team's other CAASTRO members include Dr Ramesh Bhat and Dr Willem van Straten (both from Swinburne University of Technology), Professor Michael Kramer (Max-Planck Institute for Radio Astronomy, Germany), and Professor Shri Kulkarni (California Institute of Technology, United States).

In 2011 the survey team published in the journal *Science* the discovery of a remarkable object, PSR J1719-1438. PSR J1719-1438 is a millisecond pulsar, the kind that is born when a neutron star in a binary system accretes matter from its companion and is spun up to a rotation period of hundreds of times per second. In this case, the radio pulsar rotates every 5.7 milliseconds.

Observations indicate that a close companion's gravitational tug periodically moderates the arrival times of the pulsar's radio signals. The object, slightly more massive than Jupiter, orbits the pulsar every 130 minutes at an average distance of only 600,000 kilometres – the entire system would fit inside the Sun. The companion's proximity to the pulsar allowed the discovery team to calculate how compactly this mass must be packed so the object is not tidally torn apart by the pulsar's powerful gravity. This calculation implied a maximum diameter of 60,000 kilometres (a little less than half that of Jupiter), with an astonishing density of at least 23 grams per cubic centimetre.

At these densities, planets composed primarily of hydrogen or helium are ruled out, meaning the companion must be comprised of carbon or higher elements. Theoretical calculations suggest that it is a carbon white dwarf, one that was once a massive star before losing much of its mass to the companion pulsar, spinning the latter up and spiralling out from what was once a very ultra-compact binary system.

This evolutionary link to the class of stars known as ultra-compact low-mass X-ray binaries, the novelty of the system, and the very low mass led to the publication of the discovery in *Science*. The probable lattice structure of the carbon core of the planet led to a connection with terrestrial diamond, and the system was referred to by the popular press as the "Diamond Planet", leading to an astonishing amount of media attention.



A DENSE COMPANION: The locus of the companion mass and Roche Lobe radii for PSR J1719−1438, selected ultra-compact low mass X-ray binaries and black widow millisecond pulsars for different assumed orbital inclinations. The zero-temperature mass-radius relations from Deloye and Bildsten (2003) are also shown for low-mass Helium and Carbon white dwarfs. The dotted line represents the mass-radius relation for low-mass Carbon white dwarfs computed by Lai, Abrahams & Shapiro (1991). For reference the mass and radius of Jupiter is shown with an X.

CREDIT: Bailes et al.

Unusual Millisecond Pulsars

The High Time Resolution Universe Legacy Survey team not only discovered the Diamond Planet, but also in 2011 reported the discovery of six new millisecond pulsars. All six millisecond pulsars are in binary systems, with the companions likely to be white dwarfs or very low-mass companions.

Of the new discoveries, the millisecond pulsars PSR J1502–6752 and PSR J1622–6617 are unusual amongst the population of millisecond pulsars in that they have relatively long spin periods of the order of 25 milliseconds, and yet they have short orbital periods (~2.48 and ~1.64 days, respectively) and extremely small implied masses for their companions (~0.02 and ~0.09 solar masses, respectively). The characteristics of PSR J1502-6752 in particular are currently unique, as other comparable millisecond pulsars have considerably more massive companions. This then suggests a formation mechanism that is best described as improbable and puzzling for our current understanding of millisecond pulsars.

The discovery of these six millisecond pulsars doubled the number of this class that had been found and published during this project (several more are soon to be announced). The team also reported polarisation profiles for all twelve millisecond pulsars, providing new data on the emission properties of these objects, and the sample amply illustrated the wide variety of profiles that millisecond pulsars present. Based on the results, the team has argued that (contrary to what has previously been thought) the emission heights in millisecond pulsars are a considerable fraction of the light cylinder, and hence a large fraction of millisecond pulsars show emission from both poles.

In addition, two of the dozen discoveries, PSR J1446-4701 and PSR J1125-5825, have positions coincident with gamma-ray sources identified by the team from the Fermi Gamma-ray Space Telescope. Only a small proportion of known millisecond pulsars have been detected at gamma-ray wavelengths. This research has been published in *Monthly Notices of the Royal Astronomical Society*.

New Techniques for Radio Detection

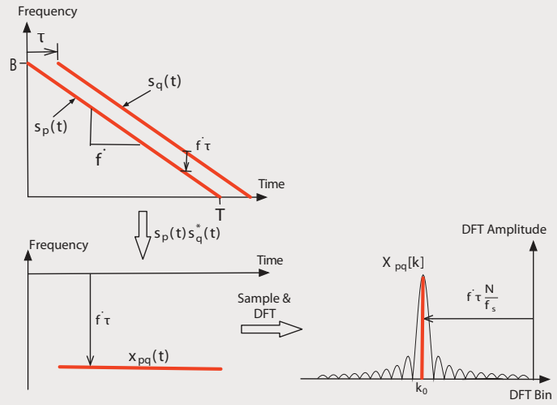
CAASTRO student Keith Bannister (University of Sydney), along with Tim Cornwell (CSIRO) has published a paper in *The Astrophysical Journal Supplement Series* on two new techniques for searching for dispersed radio pulses in interferometric data: the “Chirpolator” and the “Chimageator”.

The Chirpolator operates by correlating the frequency swept signals (or “chirps”) received by pairs of antennas, while the Chimageator grids the cross-multiplied voltages from all telescopes of an array to form an image with each sampling moment.

Pulsars are usually discovered by searching for periodic, dispersed radio emission, but new approaches such as those proposed here will greatly increase the potential for discovering new phenomena. The authors derived the principles of both techniques and proposed a number of novel optimisations. Implementation costs of the new techniques were compared with classical methods using three criteria: the operations rates before and after the integrate-and-dump stage, and the data rate directly after the integrate-and-dump stage.

When compared with classical methods, the techniques excel in the regime of sparse arrays, where they both require substantially lower data rates. The Chirpolator also requires a much lower post-integrator operations rate, although it requires more pre-integrator operations than classical techniques.

The data and operations rates required by the Chirpolator and Chimageator are well matched to future supercomputer architectures, for which the arithmetic capability will outstrip the bandwidth capability. These new algorithms are therefore exciting possibilities for deployment on future interferometers such as the Square Kilometre Array.



FINDING FAST PULSES: Schematic illustrating The Chirpolator operating with two antennas. Top left: Two linear chirps are received by antennas p and q, with one delayed by a time τ. Bottom left: After taking the product of the two voltage time series, the result x_{pq} has constant frequency over most of the duration of the chirp. Bottom right: The discrete Fourier transform of x_{pq} yields a peak at frequency k_0.

CREDIT: Bannister and Cornwell

THE DARK UNIVERSE

Theme Leader: Professor Brian Schmidt | Australian National University

What is the ultimate fate of the Universe? It has been known since the early 20th century that the Universe is expanding. The assumption was that the expansion would be slowing due to gravity, but it was unknown if gravity would eventually slow down the expansion sufficiently to stop it. By measuring how fast galaxies were expanding in the early Universe, and comparing those to galaxies in the current epoch, the total gravitational effect in the Universe could be measured.

To measure the distances to galaxies in the early Universe, type Ia supernovae (the explosions of white dwarf stars) are used as “standard candles”. Those that have been discovered in the nearby Universe have been found to be very similar in brightness, and so by discovering type Ia supernova in distant galaxies and measuring their apparent brightness, distances can be derived to a precision similar to other leading distance methodologies.

In the 1990s, when two teams of astronomers, including the High-Z Supernova Search Team led by CAASTRO’s Dark Universe theme leader Professor Brian Schmidt, compared the derived distances of the early Universe supernovae to their apparent distances calculated by their redshift, they discovered that the supernovae were too faint – they were farther away than expected. An unknown force known as Dark Energy (represented by the symbol Lambda) was gradually accelerating the Universe’s speed of expansion.

The current standard cosmological model is now one where only 4% of the Universe is made of normal atomic matter. The rest is 73% Dark Energy and 23% Dark Matter, both of which are unexplained phenomena.

The goal of CAASTRO’s Dark Universe theme is to undertake world leading experiments using Australia’s wide-field astronomical capabilities that will test the current Lambda – Cold Dark Matter cosmological paradigm. These experiments will either constrain the properties of Dark Matter and Dark Energy, or will overturn the current orthodoxy.

Testing Dark Energy with ASKAP

The Evolutionary Map of the Universe (EMU) survey with the Australian Square Kilometre Array Pathfinder (ASKAP) will perform the most comprehensive census ever undertaken of radio galaxies throughout the Universe. CAASTRO Partner Investigator Professor Ray Norris (CSIRO), together with several other CAASTRO co-authors, has shown that it will be possible to test Dark Energy using these galaxies in three different ways. Their techniques include how these radio galaxies congregate in space, how these galaxies affect the photons of the Cosmic Microwave Background through an effect known as the Integrated Sachs-Wolfe Effect, and finally, how the objects themselves are magnified by foreground galaxies.

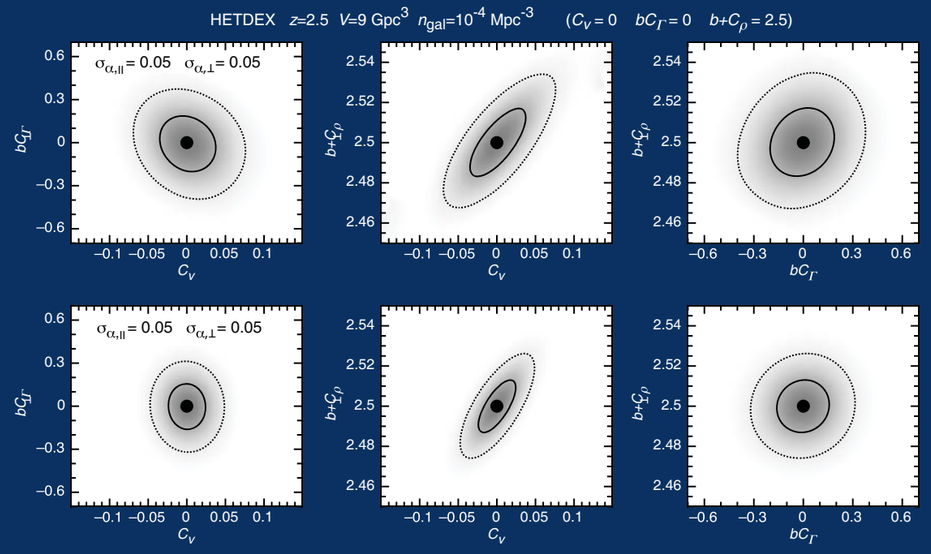
While challenging, the techniques have the potential to make some of the most constraining measurements to date on the nature of Dark Energy. This work was published in *Publications of the Astronomical Society of Australia*.

DISCOVER

The Problem of Lyman Alpha Absorption

To test the standard model for Dark Energy, astronomers are measuring the precise effects of gravity at greater and greater distances. CAASTRO's Professor Stuart Wyithe (University of Melbourne), together with Dr Mark Dijkstra (Max Planck Institute for Astrophysics), has published a paper in *Monthly Notices of the Royal Astronomical Society* in which he shows that at the largest distances planned to be probed, about 11 billion years in the past, the way we select galaxies, using their Lyman alpha emission, can interfere with many of the proposed measurements, and make them less certain.

Many proposed tests of Dark Energy use the statistical properties of how galaxies congregate in space. While the Lyman alpha emission of galaxies can make them easy to identify, the absorption of Lyman alpha from gas around the galaxies can hide some of them. This hiding gas has a pattern of congregation that is similar to the patterns of galaxies intended to be used to make precise measurements of Dark Energy. Using techniques in this paper, this problem can be at least partially accounted for, and will help these experiments to achieve their goal of testing Dark Energy in the early Universe.



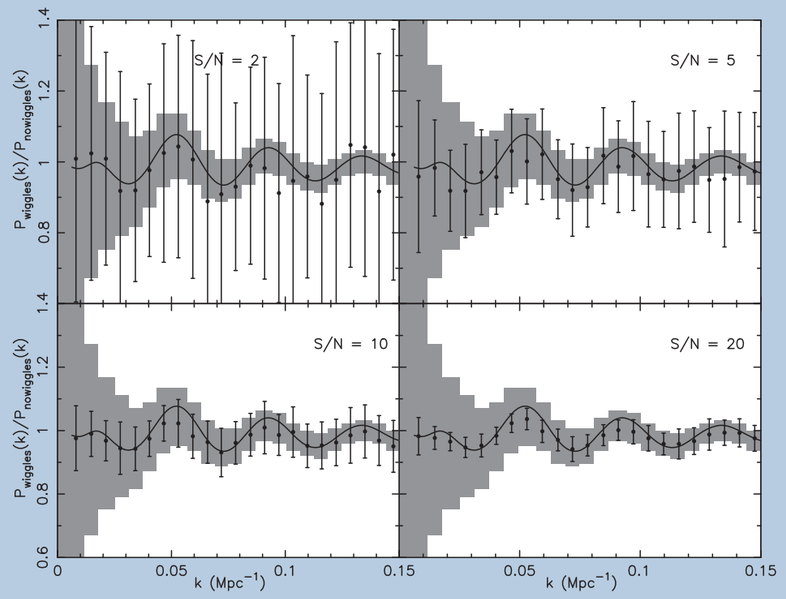
GALAXY STATISTICS: Expected constraints on power-spectrum distortions and transmission models from upcoming Lyman-alpha absorption line surveys. The six panels show contours of likelihood for various pairs of cosmological parameters. Contours of likelihood are shown at 61% and 14% of the peak likelihood.

CREDIT: Wyithe and Dijkstra

Simulating Baryonic Acoustic Oscillations

Baryon acoustic oscillations (BAOs) are sound waves that sloshed around in the Universe for its first 400,000 years. This sloshing is frozen into galaxies and gas today, with a scale that can enable astronomers to make some of the most accurate measurements of the scale of the Universe. At very large distances, corresponding to light now arriving from galaxies more than 11 billion years in our Universe's past, astronomers are now undertaking surveys to measure this acoustic scale using hydrogen gas that absorbs specific wavelengths of light in the spectra of distant quasars.

In a *Monthly Notices of the Royal Astronomical Society* paper by a CAASTRO team featuring PhD student Bradley Greig, Dr James Bolton, and Professor Stuart Wyithe (all at the University of Melbourne), have provided a new technique for rapid calculation of how this hydrogen gas is distributed in the Universe as a function of the cosmological model. Through this new approach, using graphics processor units, a standard desktop computer now takes less than a day to replicate what used to require a month-long supercomputer simulation. The greatly increased simulation scope provided by this approach will substantially improve our understanding of systematic effects in baryon acoustic oscillation experiments, and will therefore enable extraction of the best possible constraints on Dark Energy from the data.



SIMULATING THE UNIVERSE ON A LAPTOP: Comparison of BAOs calculated using a graphics processor unit with expected results from full simulations. The four panels plot the amplitude of BAOs as a function of spatial frequency for differing signal-to-noise ratios. The data points are the BAO signature recovered from a simulated Lyman-alpha dataset containing 1200 lines of sight, while the solid curve is the expected BAO signature generated from the ratio of the input linear dark matter power spectra with and without the baryon oscillation features. The shaded region displays an estimate of the cosmic variance error for the simulated survey volume.

CREDIT: Greig et al

CASE STUDIES

CAASTRO students Sarah Reeves and Kitty Lo.
Photo: Jayne Ion

National Innovation Priority Case Study

INDUSTRY ENGAGEMENT

Professor Steven Tingay | Curtin University

Mr Mehran Mossammaparast working on the EoR global signature experiment at the PSI laboratories in Fremantle, Western Australia.

The CAASTRO Evolving Universe theme project to search for the Epoch of Reionisation (EoR) global signal is an extraordinarily difficult experiment in technical astronomy. The project requires the development of very stable analogue and digital electronics and operation in an extremely radio quiet location, in order to detect the formation of the first stars and galaxies, when the Universe was less than 10% its current age.

The development of the instrumentation for this experiment is being led by the Curtin University node of CAASTRO (Project Leader: Dr Randall Wayth), with technical and engineering assistance from an industry collaborator, Poseidon Scientific Instruments (PSI), an SME based in Fremantle, Western Australia. PSI is supplying labour and materials, under contract to Curtin University, to build the analogue electronics for the experiment.

The experiment involves researchers from four of the six CAASTRO nodes, covering theory, observation, engineering and technical astronomy. Thus, the CAASTRO structure, funding and mission have allowed this experiment to be initiated, bringing together a world-class team that includes Professor Stuart Wyithe, Laureate Fellow at The University of Melbourne, WA Premier's Fellow Professor Steven Tingay at Curtin University, Professor Lister Staveley-Smith at The University of Western Australia and Professor Frank Briggs at The Australian National University, as well as postdoctoral staff and postgraduate students at these CAASTRO nodes. In addition, this project has the close involvement of the Raman Research Institute (RRI), with long-term visits to Curtin University by RRI staff planned in order to undertake joint research in 2012.

One of the PSI team, Mr Mehran Mossammaparast has joined CAASTRO in the role of part-time postgraduate Masters student at Curtin University, to work on this project, further evidence of the close collaborative relationship between CAASTRO and PSI.

Work on the first version of the instrumentation is almost complete and will be deployed for test observations in the second half of 2012.

The collaborative engagement between CAASTRO and PSI is an example of a fruitful link between academia and industry, where the demanding requirements of experimental work are helping to up-skill employees of technology companies. PSI are world leaders in the production of highly stable clocks and are able to bring that technical skill to radio astronomy instrumentation, in the process gaining skills in other areas of design and manufacture.

PSI are a willing participant with CAASTRO in this collaboration, as an entry point to the Square Kilometre Array (SKA) pre-construction era and in preparation for involvement in areas of SKA development, in particular the low frequency component of the SKA. PSI hope to benefit from the production contracts that will flow to construct the SKA itself.

Without a credible track record in advanced radio astronomy developments, companies (global multi-nationals and SMEs alike) will not be in a position to bid for work from the $2 billion SKA project. Thus, CAASTRO is assisting in this process by providing opportunities, contracts and knowledge transfer to PSI, to give the company the best chance to compete. In doing so, CAASTRO is directly advancing the National Innovation Priorities, in particular "the innovation system encourages a culture of collaboration within the research sector and between researchers and industry", toward doubling the level of collaboration between Australian businesses and universities over the next decade, and "Australian researchers and businesses are involved in more international collaborations on research and development". The SKA is a perfect example of an international collaboration where Australian industries should be aiming to participate.

Meaningful collaborations between academia and industry are often not easy to initiate or manage. The CAASTRO structure has allowed the collaboration with PSI to proceed smoothly and gain pace quickly, with both CAASTRO and PSI benefiting significantly from the engagement.

National Innovation Priority Case Study

COLLABORATION WITH PUBLICLY FUNDED RESEARCH AGENCIES

Associate Professor Scott Croom | University of Sydney

One of the key aims of CAASTRO's Evolving Universe theme is to understand how galaxies have formed and evolved over cosmic time. The overwhelming difficulty in this field is the complexity of baryonic physics, with multi-phase gas, star formation, dust, supernovae, super-massive black holes etc. all influencing the outcome of the galaxy formation process. The multi-parameter nature of galaxy formation has meant that much progress has been made over the last decade by conducting massively multiplexed surveys, allowing samples of up to one million galaxies to be constructed. These have, in turn, allowed detailed statistical analyses to be made, where the correlation between the multitudes of physical parameters can be studied.

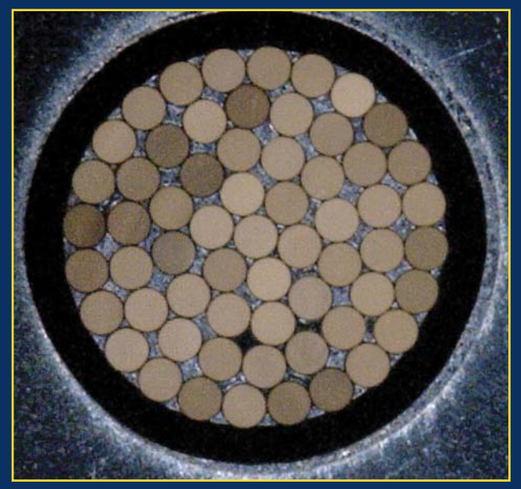
All of these major surveys have used a single optical fibre (e.g. the 2dF Galaxy Redshift Survey and the Sloan Digital Sky Survey) or slit to collect the light from each galaxy. Yet, galaxies are intrinsically complex, multi-component systems with multiple structural components (e.g. disks, bulges, halos) and experiencing elaborate interactions between the dark matter, stars, gas and super-massive black holes they contain. The use of single apertures thus loses valuable information and adds confusing biases.

What is lacking to address many of the most pressing current issues in galaxy evolution studies are surveys of similar scale, but yielding spatially resolved maps of galaxy emission. In a collaboration between The University of Sydney and the Australian Astronomical Observatory, we have developed the Sydney-AAO Multi-object Integral field spectrograph (SAMI) to specifically address this issue and take the natural next step forward in galaxy evolution studies.

SAMI in action

Central to the SAMI instrument is the use of a new astrophotonic technology, the hexabundle, developed by The University of Sydney. These are optical fibres with their cladding mostly removed and then fused together to provide a close packed array with high fill factor. SAMI uses the 1-degree field of view of the Anglo-Australian Telescope (AAT) in Coonabarabran to mount 13 hexabundles, which each contain 61 individual fibres fused together. Each hexabundle can target a different galaxy. The light is then fed via optical fibres to the AAT's AAOmega spectrograph.

The SAMI team, lead by CAASTRO Chief Investigator Associate Professor Scott Croom (University of Sydney) and including CAASTRO members Dr Julia Bryant (University of Sydney), Professor Matthew Colless and Associate Professor Andrew Hopkins (both Australian Astronomical Observatory), commissioned the SAMI instrument in July 2011. After installing the instrument at prime focus on the AAT, the first observations tested the alignment and positioning of the hexabundles. As part of this, an observer (student Sam Richards) had to ride in the top end of the AAT, something that had not been seen for some years. The alignment was confirmed, and by the end of the first night of commissioning the team had taken their first galaxy spectra. Thanks to a near real-time data pipeline, they were even able to generate a velocity maps from this early data. This early success demonstrates both the value of the ongoing collaboration between The University of Sydney and the Australian Astronomical Observatory and the enormous potential for the SAMI instrument. The first major science projects will be initiated in 2012.



The front face of a hexabundle from the SAMI instrument showing the 61 individual fibres fused together.

Photo: Samuel Richards

The SAMI plug plate assembly unit mounted onto the Prime Focus Camera. The white "splice box" connects the blue hexabundles and orange sky fibres from the brass plug-plate to the fibre bundle.

Photo: Samuel Richards

Team member Sam Richards prepares for a long cold night in the triplet top end with SAMI.

Photo: Jon Lawrence

INNOVATE

National Research Priority Case Study

SMART INFORMATION USE

Professor Matthew Bailes | Swinburne University of Technology

Many of the advances in radio astronomy over the past thirty years have come about because of the growth in computational power related to Moore's law. As a radio astronomer who has been going to the Parkes radio telescope for the past 25 years, I've become acutely aware of two things; firstly, that "The Dish", despite its awe-inspiring dimension, has not changed its collecting area for the last 50 years, and secondly, that the information technology available to us is driving most of the new scientific discoveries.

As a young PhD student I first went to Parkes in 1986 to perform observations for my thesis. Parkes was more isolated then, and making telephone calls from the tower was frowned upon because of the cost. The computer that ran the data acquisition system cost about a quarter of a million dollars and had less computational power than an iPhone. Whenever we used to send a job to the printer this overloaded the system, sometimes causing it to crash, and we had to patiently wait the 25 minutes for it to reboot. At huge expense NASA had installed a 10 megabit per second link between Parkes and Tidbinbilla, and I was part of a team that was adapting it for use in radio astronomy, linking the two largest radio telescopes in the southern hemisphere into a single instrument.

The CSIRO had built a custom correlator involving many person-years of effort, and it could, at a stretch, process the 10 MHz of bandwidth available from each of the antennas. Many senior and not-so senior scientists wrote custom software (mostly in Fortran and Pascal) to enable the correlator to adjust for the changing path length to our stars as the world rotated, and after many years our science flowed.

The paucity of computing resources available in the tower was so limited that one scientist used to bring his own (rather expensive) Macintosh computer into the tower. By attaching a 75 baud (bits per second) modem to the machine, he could link to the mainframes back in Sydney. At the time this appeared to be somewhat remarkable to me, watching him continue his work in Sydney, while 350 km away.

Fast-forwarding 25 years into the future, my team at the Swinburne University of Technology has been working on a new survey of the southern sky for fast transients and millisecond radio pulsars with a big international team from CSIRO, the University of Manchester, UK, the Max-Planck Institute for Radio Astronomy in Bonn, Germany, and Cagliari Observatory, in Sardinia, Italy. The instrumentation's ability to deliver high-quality digital data and process it in real time is astounding. Whilst in 1986 we delighted at being able to process two 10 megabit/second streams in real time, our modern instrument "BPSR" – the Berkeley-Parkes-Swinburne Recorder – takes 186,200 megabits every second and creates a digital radio spectrum every 3 microseconds that is averaged and sent to 13 computers, each some 1000 times faster than the old machine I used for my PhD. There are many stages of filtering and averaging, but within a few minutes we are using dedicated fibre optic links to transport the data to the Swinburne supercomputer at 400 megabits/second, some 5 million times faster than was possible in 1986.

Once the data arrives at Swinburne it is split two ways: one stream goes to one of three tape robots that can store up to 30 terabytes of information, and the other stream goes to a 12 teraflop supercomputer for real-time analysis. The installation of such a computer at Parkes would overheat the building! On lucky days, the supercomputer reveals new stars that we can follow-up soon after their discovery. The growth in processing power to the project is over 1 million times that available in 1986. Status information from the system is available on the web, and the whole system is the result of many years of coding in complex scientific languages and scripts.

Now when we go observing, virtually every astronomer brings their own laptop to plug into a 1 gigabit/second internet network. Our external communications have also been dramatically improved. In the control room at Parkes and in the pulsar group headquarters in Swinburne, two CISCO "telepresence" video conferencing units are deployed. Literally at the touch of a button, high-definition video with low delays and exceptional audio quality is sent between the sites, enabling the Parkes control room to "expand" to incorporate the software engineers and scientists at Swinburne. The high quality of the picture and audio makes the communication effortless, and aids in debugging faults and in boosting scientific returns.

Radio astronomy is fortunate in that it performs many independent calculations that thrive on parallel processors. The latest contributor to the growth in computational power available to astronomers is the graphics processing unit (GPU). Although more difficult to program than traditional CPUs, the rewards are immense. A single GPU can perform 1 trillion numerical calculations per second, some 100,000 times more than the old computers I used in my PhD. The cost of these units is often just a few thousand dollars.

In 2011, CAASTRO collaborators at UWA, Swinburne, CSIRO and Oxford PhD candidate Danny Price have been working on a new instrument that will soon be in operation. Dubbed "HIPSR", the system will perform both 21cm HI (Evolving Universe) and pulsar (Dynamic Universe) observations and will make liberal use of 18 GPUs delivering over 20 teraflops of computational power. The GPUs will enable the scientists to eradicate impulsive bursts of radio frequency interference by the real-time processing of 26 independent data streams. Across the continent, some of the core data transport software is being redeployed at Curtin to aid in the operation of the Murchison Widefield Array. In the US, a team at Harvard University is utilising this software for their own low-frequency Square Kilometre Array demonstrator.

2011 was also a good year for the science and techniques coming out of the CSIRO Parkes radio telescope by CAASTRO-supported personnel, and their national and international collaborators: published results include new techniques of interference rejection by Kocz et al. and the celebrated Diamond Planet discovery, as well as a host of millisecond pulsar discoveries.

The scientists and software engineers developing these supercomputing tools are developing skills that are easily transferable to other areas, such as financial modelling, telecommunications, remote sensing, defence and weather forecasting. At CAASTRO however, the new Square Kilometre Array pathfinder instruments coming online provide ample opportunities for the PhD students being trained to find gainful employment in developing the "killer-apps" for tomorrow's radio telescopes.

Acknowledgements:

The author gratefully acknowledges the cooperation and contributions of the High Time Resolution Universe survey team over many years in the development of BPSR suite of instrumentation at the Parkes 64m radio telescope run by the CSIRO's Astronomy and Space Sciences division. CAASTRO also acknowledges industry support from CISCO, Intel, Nividia, Dell and SGI in the development of these instruments.

The server for the new HI and Pulsar (HIPSR) machine. The silver boxes at the top of the rack are Reconfigurable Open Architecture Computer Hardware (ROACH) boxes, developed by the Collaboration for Astronomy Signal Processing and Electronics Research (CASPER) group at UC Berkeley. Some of the additional data processing machines can be seen in the bottom of the rack.
Jonathan Kocz

Interdisciplinary Research Case Study

MACHINE LEARNING

Dr Tara Murphy | University of Sydney

One of the main aims of the CAASTRO Dynamic Universe Theme is to conduct massive wide-field blind surveys on next generation SKA pathfinder telescopes such as ASKAP and the MWA. To fully exploit the scientific potential of these surveys, rapid multi-wavelength follow-up of any interesting transient sources will be critical. When transient events happen, we want to detect, and where possible classify, them as soon as possible, allowing us to deploy telescopes around the world in near real-time.

Hence one of the technical challenges of the Dynamic Universe theme is how to sift through the enormous amounts of data we will receive, and make judgements about what type of source we have observed through automatic classification of its light curve. This project, on machine learning classification of radio light curves, is being led by Tara Murphy at The University of Sydney, in collaboration with machine learning researchers in the School of Information Technologies at The University of Sydney and at the NASA Jet Propulsion Laboratory.

The project has involved CAASTRO postdoctoral staff, CAASTRO PhD student Kitty Lo and undergraduate project students at these institutions.

Using a set of simulated light curves representing some of the main classes of sources we expect to see with ASKAP (gamma-ray bursts, supernovae, extreme scattering events, flare stars and others), we are investigating optimal feature representation of the light curves, and the accuracy of both online and offline classification. Online classification is a particular challenge, with the goal of assigning a probabilistic estimate as soon as possible after the initial detection.

Interdisciplinary collaboration is important for this type of project as it allows us to draw on the expertise of computer science experts in selecting and testing cutting edge machine learning algorithms. We are planning a paper on this work and will implement a prototype in the ASKAP transient detection pipeline.

Results of machine learning classification of simulated VAST transient sources. To perform the classification, we first extract features from each light curve and then use a machine learning algorithm on the feature vectors. The combination of all feature representations (a) with the Random Forest classifier (b) achieved the highest classification accuracy (c).

Courtesy Umaa Rebbapragada, NASA/JPL-Caltech

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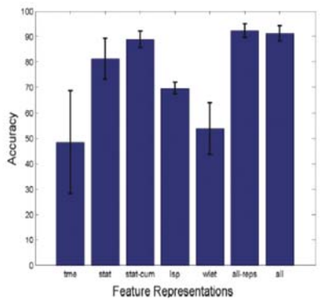

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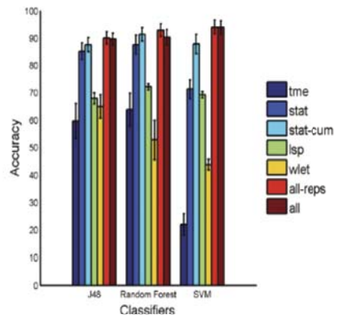

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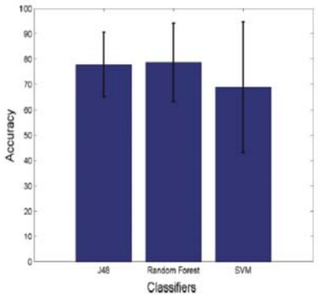


Interdisciplinary Research Case Study

GEOCHRONOLOGY DATA

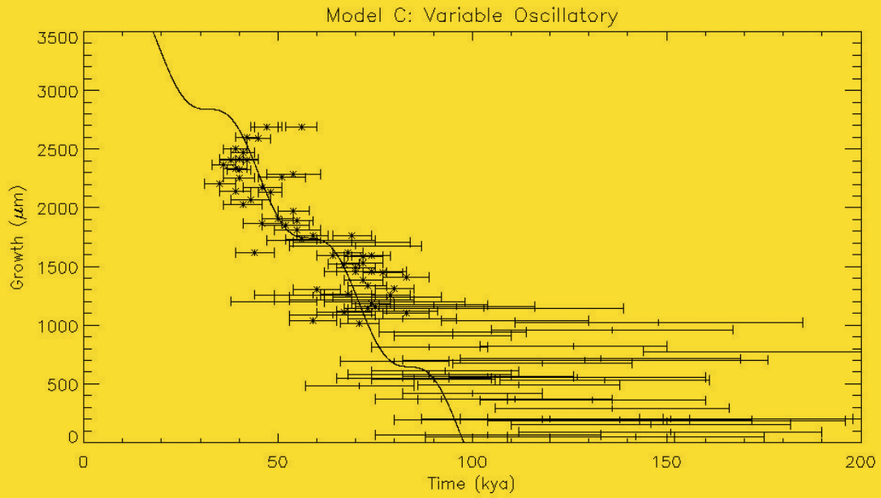
Dr Cathryn Trott | Curtin University

During 2011, the Curtin CAASTRO Node was approached by Curtin University geologists to help with the mathematical analysis of geochronology data from lunar breccia zircon samples, obtained during the Apollo missions. Dr Cathryn Trott, a CAASTRO Research Fellow within the Dynamic Universe theme, offered to perform an analysis of the dataset to fit mathematically rigorous models of dating data from two lunar sites, to determine whether they had similar geological histories, and to model the zircon growth.

In addition to this project, Dr Trott provided the analysis to model the growth rates of Western Australian opal samples, adding a rigorous foundation to the hypothesis that crystal growth rate is related to large-scale climatic conditions over the Australian continent and the rate of solar irradiance.

Astronomers are well-qualified to undertake rigorous mathematical and statistical analyses of datasets across a broad range of fields, due to the solid foundation in analytic methods that astronomy training provides. The breadth and depth of skills and knowledge within CAASTRO provides a unique environment for collaborative endeavour across a broad spectrum of scientific disciplines.

Planetary science linkages fit well within the broad CAASTRO vision, drawing upon the fundamental themes of a dynamic and evolving universe, in addition to leveraging CAASTRO's experience with handling large and sophisticated datasets, and its focus on developing innovative data methods.



Plot showing the measured ages of the opal samples, versus their position within the crystal (microns), reflecting the growth of the crystal over time (asterisks with dating measurement errors). Over-plotted is a potential fit to a model that incorporates a linear crystal growth rate plus an oscillatory component (solid line). The period of oscillations for the best-fitting model matches the measured solar insolation rate for that period in history.
Cathryn Trott

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Norris, R.P., Hopkins, A.M., Afonso, J., Brown, S., Condon, J.J., Dunne, L., Feain, I., Hollow, R., Jarvis, M., Johnston-Hollitt, M., Lenc, E., Middelberg, E., Padovani, P., Prandoni, I., Rudnick, L., Seymour, N., Umana, G., Andernach, H., Alexander, D.M., Appleton, P.N., Bacon, D., Banfield, J., Becker, W., Brown, M.J.I., Ciliegi, P., Jackson, C., Eales, S., Edge, A.C.. Gaensler, B.M., Giovannini, G., Hales, C.A., Hancock, P., Huynh, M.Y., Ibar, E., Ivison, R.J., Kennicutt, R., Kimball, A.E., Koekemoer, A.M., Koribalski, B.S., López-Sánchez, Á.R., Mao M.Y., Murphy, T., Messias, H., Pimbblet, K.A., Raccanelli, A., Randall, K.E., Reiprich, T.H., Roseboom, I.G., Röttgering, H., Saikia, D.J., Sharp, R.G., Slee, O.B., Smail, I.R., Thompson, M.A., Urquhart, J.S., Wall, J.V., Zhao, G.-B. "*EMU: Evolutionary Map of the Universe*", Publications of the Astronomical Society of Australia, 28, 215 (doi:10.1071/AS11021)

Springob, C.M., Magoulas, C., Proctor, R., Colless, M., Jones, D.H., Kobayashi, C., Campbell, L., Lucey, J., Mould, J., 2011, "*The 6dF Galaxy Survey: Stellar Population Trends Across and Through the Fundamental Plane*", Monthly Notices of the Royal Astronomical Society, in press (arXiv:1110.1916)

Wyithe, J.S.B., Dijkstra, M. "*Non-gravitational contributions to the clustering of Lyα selected galaxies: implications for cosmological surveys*", Monthly Notices of the Royal Astronomical Society, 415, 3929 (doi:10.1111/j.1365-2966.2011.19007.x)

Attendees at CAASTRO's first Annual Retreat held at Bungendore, NSW in November 2011.

STUDENT LIFE

Morag Scrimgeour

CAASTRO PhD Student
ICRAR, University of Western Australia (UWA)

I am a 2nd-year PhD student with CAASTRO based at the International Centre for Radio Astronomy Research (ICRAR) at the University of Western Australia. I completed my undergraduate degree in Mathematics & Physics at the University of St Andrews, Scotland.

After this I decided to follow my interest in cosmology, and am now doing my PhD in observational cosmology, trying to test the standard cosmological model, Lambda Cold Dark Matter, supervised by Lister Staveley-Smith (UWA), Tamara Davis (UQ) and Peter Quinn (UWA). The first part of my PhD was an analysis of the transition to large-scale cosmic homogeneity in the WiggleZ survey, working mainly with Tamara Davis (UQ) and Chris Blake (Swinburne).

I joined CAASTRO in July 2011 and am currently working on a project with CAASTRO collaborators Lister Staveley-Smith (UWA), Tamara Davis (UQ), Brian Schmidt (ANU) and Chris Blake (Swinburne), on measuring cosmology with galaxy peculiar velocities. In particular, galaxy peculiar velocities will be measured by two upcoming Australian surveys, SkyMapper (using Type Ia supernovae) and WALLABY (using radio-detected galaxies) and I will be making predictions of the cosmological information these will provide. CAASTRO is supporting these two surveys, and will give me the opportunity for frequent travel to collaborate with my supervisors and co-researchers on the project, along with opportunities to broaden my collaborations with other Australian researchers.

Benjamin McKinley

CAASTRO PhD Student
Research School of Astronomy and Astrophysics
Australian National University (ANU)

During the first year of my PhD I have been involved in an exciting new project – a precursor to the planned Square Kilometre Array (SKA) telescope known as the Murchison Widefield Array (MWA). This innovative new instrument is currently under construction in outback Western Australia, far from interfering radio signals. From the outset I have enjoyed support from the large, international MWA collaboration and CAASTRO has provided me with the opportunity to travel to Canada to meet fellow radio astronomers and learn more about studying low frequency signals originating from the early Universe.

My first degree was in electrical engineering. However my curiosity about the Universe drove me to study part time in Astronomy and Astrophysics while working full time as an engineer in the Air Force. It was during an undergraduate research course at the ANU that I met my current PhD supervisor. During our first meeting he seemed so excited about the little dots on his screen that I later found out to be distant radio galaxies, imaged with the MWA.

Before I began my PhD I was concerned that I wouldn't have what it takes to be a researcher (in fact I had no idea what that really was!). However I have found that with the right people surrounding you and enough self-motivation and curiosity, scientific research is a career that anyone with the right motivation can get into and enjoy.

I believe it is also important for scientists to communicate their research with a general audience and encourage young people to learn about the world around them through science. CAASTRO is an excellent platform for this and has already provided me with science communication training and the opportunity to encourage the next generation of scientists through 'CAASTRO in the Classroom'.

I am looking forward to the next two and a half years of my PhD and a fulfilling research career beyond that. I feel like I am coming in to astronomy at the beginning of an exciting new era, with many new discoveries just waiting to be made.

Kitty Lo

CAASTRO PhD Student
University of Sydney

I am a PhD student at the University of Sydney and my supervisors are Tara Murphy and Bryan Gaensler. I have a double degree in Computer Engineering and Physics from the University of New South Wales. After my undergraduate studies, I spent a few years in the business world working as a management consultant. My love of astronomy eventually enticed me back to pursue a PhD degree. My PhD project is on radio transients which fits into CAASTRO's Dynamic Universe research theme.

For the first part of my PhD, I was studying a unique periodic radio star called CU Virginis. My paper titled "Observations and modelling of pulsed radio emission from CU Virginis" has just been accepted to Monthly Notices of the Royal Astronomical Society. At the moment, I am working on automatic classification algorithms for the Variable and Slow Transients (VAST) survey on the Australian Square Kilometre Array Pathfinder (ASKAP). VAST will monitor millions of sources in the sky once a day to look for transient events. Finding interesting events in such a massive data set will be a computational challenge which hopefully my PhD project will contribute towards solving. CAASTRO provides exceptional opportunities for students to collaborate and network with other researchers in the field. It was amazing to meet world-class scientists like Brian Schmidt and Shri Kulkarni at the 2011 CAASTRO retreat.

2011 CAASTRO STUDENTS

University of Sydney

Mr Keith Bannister
THESIS TITLE *Astrophysical radio transients: surveys and techniques*
SUPERVISORS Bryan Gaensler, Tara Murphy, Tim Cornwell

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

Ms Sarah Reeves
THESIS TITLE *HI and OH absorption line studies of nearby galaxies*
SUPERVISORS Elaine Sadler, Tara Murphy, Baerbel Koribalski (CSIRO)

University of Melbourne

Mr Loren Bruns Jr
THESIS TITLE *Ly-α emitters as a probe of galaxy formation and ionization history*
SUPERVISORS Stuart Wyithe, Rachel Webster

Mr Bradley Greig
THESIS TITLE *Lyman alpha forest and Lyman alpha emitters as cosmological probes of dark energy*
SUPERVISORS Stuart Wyithe, Jamie Bolton

Ms Christina Magoulas
THESIS TITLE *Properties of Galaxies from the 6df Galaxy Survey*
SUPERVISORS Rachel Webster, Jeremy Mould (Swinburne), Matthew Colless (AAO)

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

Australian National University

Mr Ben McKinley
THESIS TITLE *A Multi-Frequency, Spatially Resolved Polarisation Study of the Giant Lobes of Centaurus A at Low Frequencies*
SUPERVISOR Frank Briggs

Mr Jongwhan Rhee
THESIS TITLE *Cosmic Hydrogen – Fuel for Star Formation and Tracer of Baryon Flow*
SUPERVISOR Frank Briggs

Ms Sharon Rapoport
THESIS TITLE *Gamma-ray bursts and exploding stars*
SUPERVISOR Brian Schmidt

Curtin University

Mr Mehran Mossammaparast
THESIS TITLE A *Radiometric Receiver for Measuring Red-Shifted 21cm Hydrogen Monopole During the Epoch of Reionisation*
SUPERVISORS Steven Tingay, Randall Wayth

University of Western Australia

Ms Morag Scrimgeour
THESIS TITLE *Measuring Cosmology with Motion in the Universe*
SUPERVISORS Lister Staveley-Smith, Peter Quinn and Tamara Davis (UQ)

NAOC, China

Mr Tao Hong
THESIS TITLE *Cosmological Structure and HI Observations*
SUPERVISORS Jinlin Han, Lister Staveley-Smith (UWA)

CAASTRO LAUNCH

The CAASTRO Launch was held on the evening of 12 September 2011 at Sydney Observatory. Her Excellency Professor Marie Bashir AC CVO, Governor of New South Wales and Chancellor of The University of Sydney officially launched CAASTRO.

A great night was had by all. All attendees and even passers-by were impressed to see the CAASTRO logo projected onto the walls and domes of Sydney Observatory.

CAASTRO was also fortunate that Sydney Observatory agreed to display the historical information from the very first all-sky survey of the sky, the Carte du Ciel (Chart of the sky). CAASTRO sees itself as the 21st century descendant of the Astrographic Catalogue and Carte du Ciel projects.

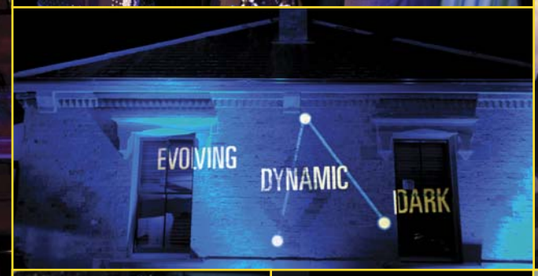
Left: Her Excellency Marie Bashir AC CVO, Governor of NSW and Chancellor of The University of Sydney.

Middle: Dr Alan Finkel AM, Chancellor of Monash University, Chair CAASTRO Advisory Board

Right: Professor Bryan Gaensler, CAASTRO Director

Photos: Jayne Ion

Sydney Observatory is part of the Powerhouse Museum.



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

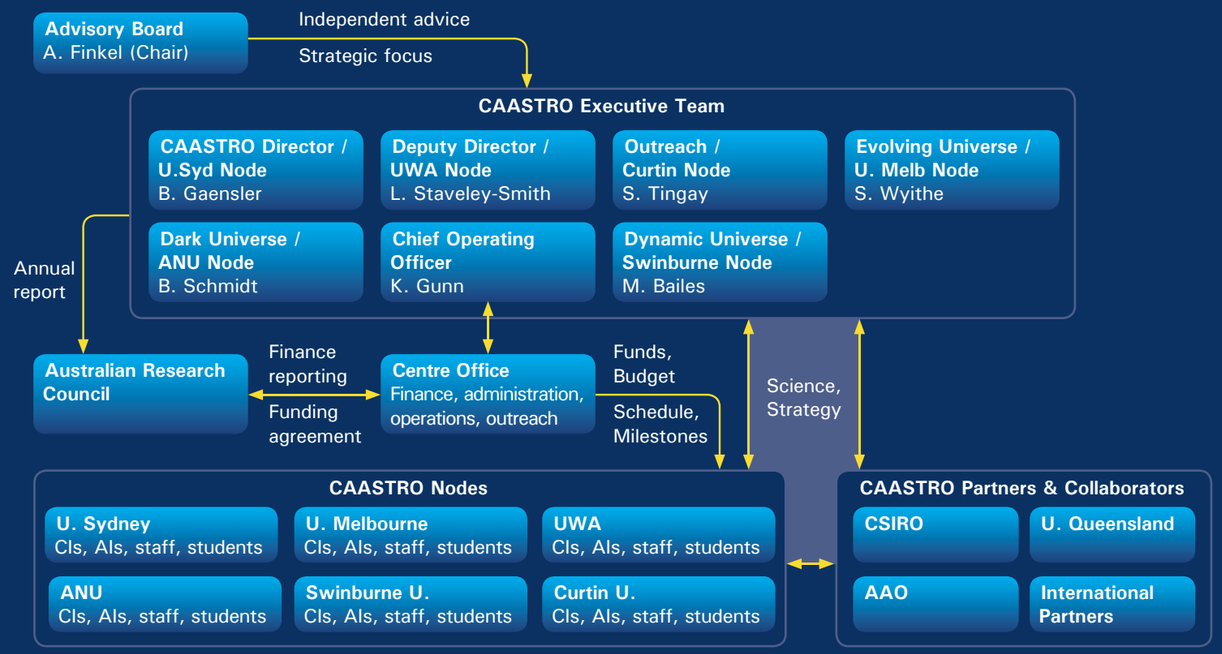
Professor Lister Staveley-Smith Deputy Director

Ms Kate Gunn Chief Operating Officer

In 2011, the CAASTRO Executive met 11 times, including face-to-face meetings at The University of Melbourne, The University of Sydney, ICRAR and Swinburne University of Technology. Area meetings were also held throughout the year in Sydney, Canberra, Melbourne and Perth. All the CAASTRO Collaboration Partners signed a Collaboration Agreement which sets out the way the research partnership will operate. In addition a CAASTRO Multi-Institute Agreement (MIA) was signed by all the CAASTRO partners.

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 2011, including a two day planning meeting held in Perth in August. The Board considered matters of strategy, responses to the changing external environment, the Centre research program, collaboration across distances, community outreach and industry engagement. They have also met with our students, researchers and professional staff.

Dr Alan Finkel AM FTSE is the Chancellor of Monash University and Chair of the CAASTRO Advisory Board. Dr Finkel is an electrical engineer, neuroscientist and entrepreneur, and has extensive experience in basic research, commercialisation, government, education and outreach.

CHAIR
Dr Alan Finkel AM
Chancellor
Monash University

MEMBER
Ms Soula Bennett
Director
Quantum Victoria

MEMBER
Mr Geoffrey Burchfield
Director
National Youth Science Forum

MEMBER
Prof Phil Diamond
Chief
CSIRO Astronomy & Space Science

MEMBER
Prof Bryan Gaensler
CAASTRO Director

MEMBER
Prof Martha Haynes
Goldwin Smith Professor of Astronomy
Cornell University

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

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

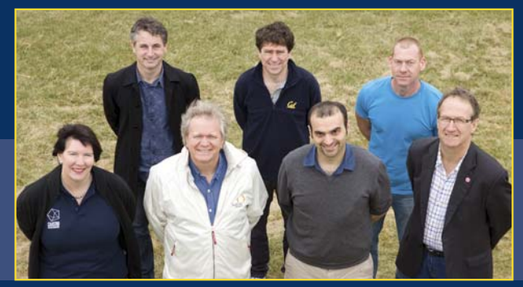
MEMBER
Mr Guy Robinson
Systems Architect
Pawsey Supercomputing Centre, CSIRO

MEMBER
Dr Jesse Shore
Science Communicator
Prismatic Sciences

MEMBER
Dr Ziggy Switkowski
Chancellor
RMIT University

CAASTRO Executive

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



CAASTRO MEMBERSHIP

The University of Sydney	Administering Organisation
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
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

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 will be normally based in Australia, and will typically be 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

2011 was an exciting year for CAASTRO with many of our team receiving awards and honours for their achievements.

NOBEL PRIZE IN PHYSICS

CAASTRO's Dark Universe theme leader Professor Brian Schmidt (Australian National University) shared the 2011 Nobel Prize in Physics "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae." Two teams studying extremely distant supernovae made the discovery in 1998. The accelerating expansion of the Universe is one of the core research components of CAASTRO's Dark Universe theme.

AUSTRALIAN LAUREATE FELLOWSHIP & MALCOLM MCINTOSH PRIZE

CAASTRO's Evolving Universe theme leader Professor Stuart Wyithe (University of Melbourne) received an Australian Laureate Fellowship from the ARC, worth $2.6 million over five years. The Fellowship project is to study the first galaxies and the Epoch of Reionisation.

Professor Wyithe was also the recipient of the Malcolm McIntosh Prize for Physical Scientist of the Year at the Prime Minister's Prizes for Science for his work on the early Universe.

PAWSEY MEDAL

CAASTRO Director Professor Bryan Gaensler (University of Sydney) received from the Australian Academy of Science the 2011 Pawsey Medal for research in physics for his pioneering studies of cosmic magnetism. Professor Gaensler's development of new spectropolarimetric techniques has enabled him to explore what role magnetism plays in the Universe, both locally in the Milky Way and in distant galaxies.

ARC FUTURE FELLOWSHIP

CAASTRO's Associate Investigator Professor Chris Blake (Swinburne University of Technology) has received $573,000 in funding for the period 2011 – 2015 for work on exploring the nature of Dark Energy with Australian galaxy surveys.

QUEENSLAND YOUNG TALL POPPY SCIENCE AWARD AND AIP WOMEN IN PHYSICS LECTURESHIP

CAASTRO's Associate Investigator Dr Tamara Davis (University of Queensland) received the 2011 Queensland Young Tall Poppy Science Award at the Queensland Premier's Science and Innovation Reception. The award and prize of $10,000 recognises Dr Davis's excellence in early career research and a passion for communicating science to the public. This was also illustrated with her receipt earlier in 2011 of the Australian Institute of Physics Women in Physics Lectureship, which has seen her embark on a schedule of talks around Australia.

Also in 2011, together with researchers from Denmark, Dr Davis earned 4th spot on Physics World magazine's top 10 scientific breakthroughs, for developing a groundbreaking method to measure cosmic distances in the Universe using light from quasars.

GRUBER PRIZE IN COSMOLOGY

CAASTRO Partner Investigator Professor Carlos Frenk, the Director of the Institute of Computational Cosmology at Durham University, was a recipient of the 2011 Gruber Prize in Cosmology for the work that he and colleagues had done in modelling the large-scale distribution of matter in the Universe.

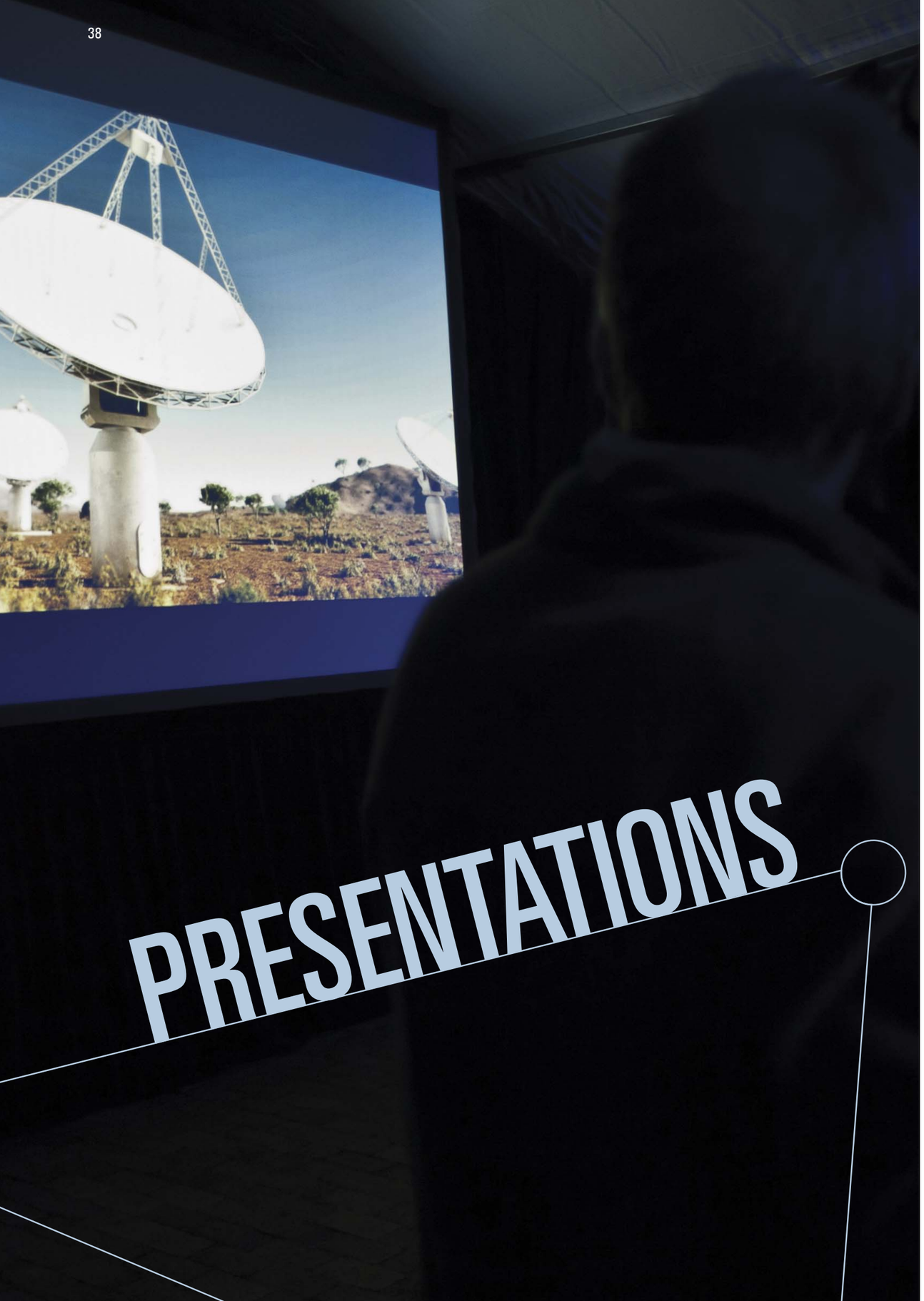
NOBEL PRIZE CEREMONY | ***The Nobel Foundation 2011*** | ***Photos: Frida Westholm***

Nobel Prize Medal
Brian Schmidt

PRIME MINISTER'S PRIZES FOR SCIENCE | ***Tamara Davis***

PAWSEY MEDAL | ***Photo: Mark Graham***

YOUNG TALL POPPY AWARD | ***Tamara Davis***



Invited talks 2011

Major Conferences

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

Pulsar Populations
Matthew Bailes, Fab Five Fest, Puerto Rico, April 2011

The Magnetic Milky Way
Bryan Gaensler, Understanding Galactic and Extragalactic Foregrounds, Zadar, Croatia, May 2011

The Evolving HI Universe with DINGO
Martin Meyer, Gas in Galaxies: from Cosmic web to molecular clouds, Kloster Seeon, Germany, June 2011

Diffuse Radio Emission from the Milky Way
Bryan Gaensler, Novel Telescopes for 21 cm Cosmology Workshop, Penticton, Canada, June 2011

Early Cosmic Web
Stuart Wyithe, Gas in Galaxies: from Cosmic web to molecular clouds, Kloster Seeon, Germany, June 2011

The Gas Accretion History of the Milky Way: Theory
Carlos Frenk, Gas in Galaxies: from Cosmic web to molecular clouds, Kloster Seeon, Germany, June 2011

Supernovae: Remarkable Physics Triggering Extraordinary Stellar Explosions
Brian Schmidt, Rossi Lecture Series, Italy, June 2011

Type Ia Supernovae, The Accelerating Cosmos, and Dark Energy
Brian Schmidt, Rossi Lecture Series, Italy, June 2011

Peering back in time: Using Stellar explosions to chronicle the History of Our Universe.
Brian Schmidt, Rossi Lecture Series, Italy, June 2011

Next Generation 2 micron survey: Beyond VISTA
Jeremy Mould, Scientific Committee on Antarctic Research - Astronomy and Astrophysics from Antarctica (SCAR AAA 2011), Australia, June 2011

Studying Supernovae in the ELT-LSST-JWST Era
Brian Schmidt, Supernovae and Their Host Galaxies, Sydney, Australia, June 2011

Sub Chandra SN Models
Stuart Sim, Supernovae and Their Host Galaxies, Sydney, Australia, June 2011

VAST: Exploring the Dynamic Radio Sky with the Australia SKA Pathfinder
Tara Murphy, Supernovae and Their Host Galaxies, Sydney, Australia, June 2011

CAASTRO
Lister Staveley-Smith, 2011 ASA meeting, Adelaide, Australia, July 2011

SkyMapper - part of Dark and Dynamic
Brian Schmidt, 2011 ASA meeting, Adelaide, Australia, July 2011

Cosmology 2011: Big Questions for the Decade
Brian Schmidt, 2011 ASA meeting, Adelaide, Australia, July 2011

Extreme Events: exploring the radio transient sky
Tara Murphy, 2011 ASA meeting, Adelaide, Australia, July 2011

HI in Galaxies, near and far
Frank Briggs, A Quarter Century of DLAs, Ringberg, Germany, July 2011

Type Ia supernovae from sub-Chandrasekhar mass white dwarfs
Stuart Sim, IAU Symposium 281: Binary paths to Type Ia supernova explosions. Padova, Italy, July 2011

The Square Kilometre Array
Lister Staveley-Smith, Feeding the Giants 2011 Workshop, Ischia Napoli, Italy, September 2011

New wide-field optical surveys
Brian Schmidt, New Horizons in Time Domain Astronomy, Oxford, UK, September 2011

Explosive events in the cosmos
Shri Kulkarni, New Horizons in Time Domain Astronomy, Oxford, UK, September 2011

Pulsars, SKA and Time Domain Studies in the Future
Michael Kramer, New Horizons in Time Domain Astronomy, Oxford, UK, September 2011

Other Presentations

Conferences, Workshops, Colloquia, Project/Collaborative Meetings

Near the end: radio transients, the Chirpolator and the little telescope that might have
Keith Bannister, Supernovae and Their Host Galaxies, Sydney, Australia, April 2011

VAST: An ASKAP Survey for Variables and Slow Transients
Tara Murphy, ThunderKAT Workshop, South Africa, April 2011

MWA Observational Strategy and Early Results
Frank Briggs, EoR Foregrounds Meeting, Zador, Croatia, May 2011

The WiggleZ Dark Energy Survey
Tamara Davis, Experimental Physics Seminar Series, University of Queensland, Australia, May 2011

Moon as 'Calibrator'
Frank Briggs, LOFAR EoR Collaboration Meeting, Zadar, Croatia, May 2011

Introduction to Pulsars
Matthew Bailes, Cagliari Single Dish Workshop, Pula, Sardinia, Italy, June 2011

RFI and other constraints
Frank Briggs, EoR + 21cm BAO Workshop, Canada, June 2011

Murchison Widefield Array
Steven Tingay, Novel Telescopes for 21 cm Cosmology Workshop, Penticton, Canada, June 2011

Little Things
Se-Heon Oh, Gas in Galaxies: from Cosmic web to molecular clouds, Kloster Seeon, Germany, June 2011

The Square Kilometre Array
Lister Staveley-Smith, Gas in Galaxies: from Cosmic web to molecular clouds, Kloster Seeon, Germany, June 2011

The Cosmic Evolution of Molecular Gas in Galaxies, Chris Power, Gas in Galaxies: from Cosmic web to molecular clouds, Kloster Seeon, Germany, June 2011

Gas in Galaxies: Predictions from Semi-analytic Models
Guinevere Kauffmann, Gas in Galaxies: from Cosmic web to molecular clouds, Kloster Seeon, Germany, June 2011

WiggleZ Results
Tamara Davis, Dark Cosmology Centre, Copenhagen, Denmark, June 2011

Using the Moon as thermal comparison load for detecting the EoR global signal
Frank Briggs, MWA Project Meeting, USA, June 2011

Imaging Bright Sources
Frank Briggs, MWA Project Meeting, USA, June 2011

Dark Energy
Brian Schmidt, Harley Wood Winter School, Adelaide, Australia, July 2011

Testing Galaxy Formation Models with Next Generation HI Surveys
Chris Power, 2011 ASA meeting, Adelaide, Australia, July 2011

Large-scale cosmic homogeneity in the WiggleZ survey
Morag Scrimgeour, 2011 ASA meeting, Adelaide, Australia, July 2011

New Surveys with the SKA Molonglo Pathfinder
Greg Madsen, 2011 ASA meeting, Adelaide, Australia, July 2011

Results of the WiggleZ Dark Energy Survey
Tamara Davis, Particle Astrophysics, Strings and Cosmology (PASCO2011), Cambridge, UK, July 2011

Dynamic Universe - Explosive Ideas about Massive Stars
Brian Schmidt, AlbaNova Centre, Stockholm, Sweden, August 2011

Surveying The Southern Sky with SkyMapper: Learning about Core Collapse Supernovae
Brian Schmidt, AlbaNova Centre, Stockholm, Sweden, August 2011

Large-scale cosmic homogeneity in the WiggleZ survey
Morag Scrimgeour, COSMO11 International Conference on Particle Physics and Cosmology, Porto, Portugal, August 2011

Source Detection with next generation widefield interferometers
Cath Trott, Astrophysics Seminar, University of Melbourne, Australia, August 2011

Impact of new science and techniques on the SKA-low Design Reference Mission
Frank Briggs, AAVP Path to SKA-low Perth, Australia, September 2011

Cosmic Confusion
Tamara Davis, Flinders University Colloquium, Adelaide, Australia, September 2011

The WiggleZ Dark Energy Survey
Tamara Davis, University of Adelaide Colloquium, Australia, September 2011

The evolution of hot and cold mode accretion
Scott Croom, First eROSITA International Conference, Garmisch-Partenkirchen, Germany, September 2011

Murchison Widefield Array
Daniel Mitchell, SKA Rutherford Innovation Showcase, Wellington, New Zealand, September 2011

Radio Emission from CU Virginis
Kitty Lo, ATUC Science Day, ATNF, Marsfield, Australia, October 2011

Parkes Update
Matthew Bailes, CASPER 2011 Workshop, Pune, India, October 2011

The 2011 Nobel Prize
Tamara Davis, Colloquium, University of Queensland School of Mathematics and Physics, Brisbane, Australia, October 2011

Millisecond Pulsar Hunting
Matthew Bailes, Parkes 50th Meeting, Australia, October 2011

Searching for fast transients with interferometric arrays
Ramesh Bhat, Time Domain Radio Astronomy, CASS, Australia, October 2011

Accelerating Universe
Brian Schmidt, AURA Oversight Council for Gemini (AOC-G), Hilo, USA, October 2011

Results of automatic, high time resolution GRB follow-up with the Parkes 12m
Keith Bannister (CSIRO), Time Domain Radio Astronomy, CASS, Australia, October 2011

Design and performance of fast transients detectors
Cath Trott, ATUC Science Day, ATNF, Marsfield, Australia, October 2011

VAST : A real-time pipeline for detecting radio transients and variables on the Australian SKA Pathfinder (ASKAP) telescope
Jay Banyer, Astronomical Data Analysis Software and Systems Conference, Paris, France, November 2011

VAST Status Update
Tara Murphy, ASKAP Science Meeting, CASS, Australia, November 2011

Cosmology with ASKAP: what will we learn?
Chris Blake, WALLABY simulations meeting, Sydney, Australia, November 2011

Massively multiplexed IFU surveys: dissecting galaxy evolution
Scott Croom, ESO, Garching, Germany, October 2011; Imperial College, London, UK, November 2011; University of Hertfordshire, UK, November 2011; University of Leeds, Leeds, UK, November 2011; University of Oxford, Oxford, UK, November 2011; Yale University, USA, November 2011; Liverpool JMU, UK, December 2011; Durham University, Durham, UK, December 2011; and, University of Portsmouth, Portsmouth, UK, December 2011

Centaurus A observations with MWA
Ben McKinley, MWA Project Meeting, Melbourne, Australia, December 2011

Radio Emission and Magnetic Fields in Supernova Remnants and Pulsar Wind Nebulae
Bryan Gaensler, Phases of Late Stellar Evolution, Macquarie University, Australia, December 2011

Large Scale Structures - series of 5 lectures
Tamara Davis, Transregio Winter School on Cosmology, Tonale, Italy, December 2011

Accelerating Universe
Brian Schmidt, Uppsula University, Sweden and Lund University, Sweden, December 2011

AGB Evolution
Jeremy Mould, Macquarie MQAAA 1st Workshop on AGB stars, Australia, December 2011

Searching for Transient and Variable Radio Sources in Murchison Wide-Field Array Data
Martin Bell, MWA Project Meeting, Melbourne, Australia, December 2011

RTS Status update
Daniel Mitchell, MWA Project Meeting, Melbourne, Australia, December 2011

MWA Calibration Limits: application to EoR observations
Randall Wayth, MWA Project Meeting, Melbourne, Australia, December 2011

Multi-frequency imaging of Centaurus A
Ben McKinley, MWA Project Meeting, Melbourne, Australia, December 2011

Long Wave Array Status
Steven Tremblay, MWA Project Meeting, Melbourne, Australia, December 2011

32T Transient Detection Pipeline, Tara Murphy, MWA Project Meeting, Melbourne, Australia, December 2011

Visits to overseas laboratories and facilities - 2011

James Allison	ASTRON Dwingaloo, The Netherlands
Matthew Bailes	Keck telescope, Hawaii, USA
Matthew Bailes	Arecibo 305m, Puerto Rico
Matthew Bailes	Bonn 100m telescope, Germany
Matthew Bailes	University of California, Berkeley, USA
Matthew Bailes	MPI for Radio Astronomy, Germany
Matthew Bailes	GMRT, India
Matthew Bailes	GMRT Headquarters, India
Ramesh Bhat	GMRT, India
Chris Blake	University of British Columbia, Canada
Chris Blake	University of California, Berkeley, USA
Chris Blake	University of Canterbury, New Zealand
Frank Briggs	National Radio Astronomy Observatory (NRAO), USA
Scott Croom	Yale University, USA
Scott Croom	Astrophysical Institut Potsdam, Potsdam, Germany
Scott Croom	European Southern Observatory, Munich (ESO), Germany
Tamara Davis	Dark Cosmology Centre, Niels Bohr Institute, University of Copenhagen, Denmark
Tamara Davis	Alba Nova, Stockholm University, Sweden
Bryan Gaensler	Pushcino Observatory, Russia
Bryan Gaensler	DRAO, Penticton, Canada
Bryan Gaensler	University of Oxford, UK
Bryan Gaensler	Harvard University, USA
Hansik Kim	Korea Astronomy & Space Science Institute, Korea
Jonathon Kocz	University of California, Berkeley, USA
Jonathon Kocz	Harvard- Smithsonian Centre for Astrophysics, USA
David Lagattuta	ASTRON, The Netherland
Daniel Mitchell	The Museum of New Zealand, New Zealand
Jeremy Mould	Palomar Observatory, USA
Lister Staveley-Smith	ALMA Observatory, Chile
Steven Tingay	DRAO, Penticton, Canada

PUBLIC TALKS

TEDxSydney

TED is a US based not-for-profit enterprise devoted to the propagation of "Ideas Worth Spreading". TED started out in 1984 as a conference bringing together people from three worlds: Technology, Entertainment & Design. To provide the TED concept with global reach, TED has created a program called TEDx, a program of local, self-organised events that bring people together to share a TED-like experience.

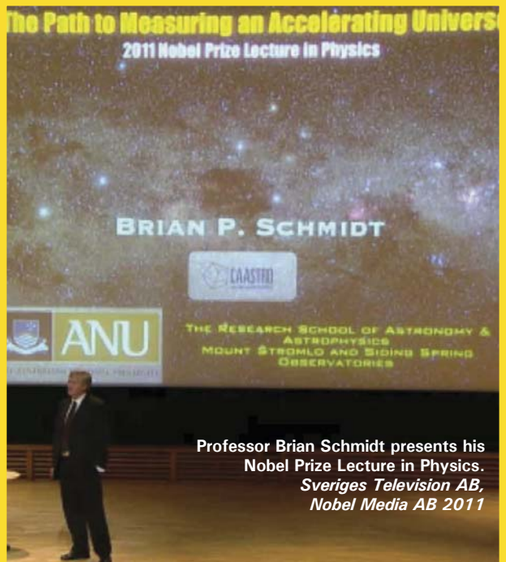
The premier TEDx event on the Australian calendar is TEDxSydney, which in 2011 was held on 28 May at CarriageWorks in inner Sydney. In a spectacular program that included The Chaser's Craig Reucassel, MacArthur Fellow Saul Griffith and musicians Daniel Johns and Paul Kelly, CAASTRO Director Bryan Gaensler was the day's opening speaker. Prof Gaensler's talk, "A New Way of Looking at the Sky", presented the CAASTRO vision to 800 audience members, another 1000 people watching on the big screen outside the theatre, 48,000 people following the online stream, and another 80,000 listening to live coverage on ABC Radio National. Gaensler's talk was subsequently posted to YouTube, where it has been downloaded more than 1000 times. Another CAASTRO investigator will soon be announced as one of the headline speakers for TEDxSydney 2012 - watch this space!

Professor Bryan Gaensler presents at TEDxSydney. *Photos: Enzo Amato*

Nobel Lecture: The Path to Measuring Cosmic Acceleration

The Nobel Prize in Physics is awarded by the Royal Swedish Academy of Sciences. According to the statutes, the Nobel Laureates are required "to give a lecture on a subject connected with the work for which the prize has been awarded".

Professor Brian Schmidt delivered his Nobel Lecture on 8 December 2011, at Aula Magna, Stockholm University. He was introduced by Professor Börje Johansson, Chairman of the Nobel Committee for Physics. While Professor Schmidt's lecture was on science discovered prior to CAASTRO, he acknowledged his CAASTRO affiliation in his opening slide of the Nobel Lecture.



Professor Brian Schmidt presents his Nobel Prize Lecture in Physics. *Sveriges Television AB, Nobel Media AB 2011*

PUBLIC LECTURES 2011

"The First Stars in the Universe", National Museum of Natural Science, National Museum of Natural Science, Taiwan, Mar 2011, Rachel Webster

"Black Holes: the heart of a galaxy", National Taiwan University, Taiwan, Mar 2011, Rachel Webster

"The First Stars in the Universe", Taipei Astronomical Museum, Taiwan, Mar 2011, Rachel Webster

Super-luminous supernovae and the exploration of the optical transient sky, National Astronomical Observatory, China, Apr 2011, Fang Yuan

Discover the SKA, Sydney, Australia, Apr 2011, Bryan Gaensler

Science, Speculation and Society: The Science behind the Fiction, Sydney, May 2011, Bryan Gaensler

TEDxSydney 2011, Sydney, May 2011, Bryan Gaensler

Surveying the Southern Sky with SkyMapper, Colloquium, Institut d'Astrophysique de Paris (IAP), Paris, France, Jun 2011, Brian Schmidt

School of Astronomy, Macquarie University Association for Astronomy, Sydney, Aug 2011, Tara Murphy

'Women in Physics Lecture', Sydney, Sep 2011, Tamara Davis

Wollongong Science Centre, Public Talk, 'The Dark Side', Wollongong, Sep 2011, Tamara Davis

Sydney Observatory, Public Talk, 'The Dark Side', Sydney, Sep 2011, Tamara Davis

Australian National University, Public Lecture, 'The Dark Side', Canberra, Sep 2011, Tamara Davis

University of Tasmania, Public Lecture, Hobart, Sep 2011, Tamara Davis

RiAUS, Public Lecture, Adelaide, Sep 2011, Tamara Davis

Discovery of a diamond planet, Pune, India, Oct 2011, Matthew Bailes

'The Dynamic Radio Sky' at the Astronomical Society of Western Australia (ASWA), Perth, Oct 2011, Randall Wayth

Astro Tour, Swinburne, Oct 2011, Jonathan Kocz

University of Queensland, Public Lecture, Brisbane, Oct 2011, Tamara Davis

'Celestial Teapot', Mornington Skeptics Society, Hastings, Victoria, Oct 2011, Rachel Webster

Macarthur Astronomical Society, Sydney, Nov 2011, Bryan Gaensler

Completion Seminar: "Fitting the Near-Infrared Fundamental Plane relation of Early-Type Galaxies', Hercus Theatre, University of Melbourne, Nov 2011, Christina Magoulas (PhD)

"The State of the Universe", Blackburn Uniting Church, Victoria, Nov 2011, Rachel Webster

Australian Institute of Physics Victorian Branch, Nobel Prize in Physics Public Lecture, Swinburne, Nov 2011, Warrick Couch

Nobel Prize Lecture- The Path to Measuring Cosmic Acceleration, Aula Magna, Stockholm University, Sweden, Dec 2011, Brian Schmidt

Australian Embassy Talk, Australian Astronomer, Australian Embassy, Sweden, Dec 2011, Brian Schmidt,

Accelerating Universe, Uppsula University, Sweden, Dec 2011, Brian Schmidt

Accelerating Universe, Lund University, Sweden, Dec 2011, Brian Schmidt

Other Public Talks by CAASTRO Members

Radio, TV and Interviews (22)

Education and Training Sessions (16)

School Talks (19)

Science Awareness Talks/Activity (13)

VISITORS TO CAASTRO

International Visitors to CAASTRO in 2011

Jon Bittner
Harvard University, USA

Shami Chatterjee
Cornell, USA

Jayaram N Chenglaur
NCRA (TIFR), Pune, India

Steve Croft
UC Berkeley, California, USA

Mo Ganeshalingham
UC Berkeley, USA

Yashwant Gupta
NCRA (TIFR), Pune, India

Andrew Johnson
University of Canterbury, New Zealand

Nick Kaiser
Institute for Astronomy, USA

Guinevere Kauffmann
Max-Planck Institut Astrophysics, Germany

Markus Kronenberg
MPA, Germany

Shri Kulkarni
Caltech, USA

Daniel Mitchell
Harvard-Smithsonian Center for Astrophysics, USA

Ruediger Pakmor
MPA, Germany

John Peacock
University of Edinburgh, Scotland

Philip Podsiadlowski
University of Oxford, UK

Umaa Rebbapragada
NASA JPL, USA

Jeff Silverman
UC Berkeley, USA

Stefan Taubenberger
MPA, Germany

Mark Wagner
UC Berkeley, USA

WORKSHOPS

Participants at the Gas in Galaxies Conference
Elaine Sadler

Participants at Novel Radio Telescopes for 21cm Cosmology in the radio-quietness of Penticton, Canada.
Steven Tingay

Participants at the Planning for Cosmology Workshop
Chris Blake

Women in Astronomy | May 2011

Australia's first ever "Women in Astronomy Workshop" was held on 13 May and was co-sponsored by CAASTRO.

This workshop was organised as part of the Women in Astronomy Chapter of the Astronomical Society of Australia and took place at CSIRO Astronomy and Space Science in Sydney. The reduction in the percentage of women at each career step is an issue that affects everyone, as women and men are equally talented and deserve equal opportunity, and full participation of men and women will maximise excellence in the field.

Seventy-five people (six belonging to CAASTRO) from 16 institutes across Australia registered, and the whole process was very positive. Guest speakers included Dr Ros Dubs (Chair, Space Industry Innovation Council) and Nicole McKenna (Vice President, National Foundation for Australian Women).

The aim of the workshop was to discuss issues women face during their astronomy careers and approaches that can be implemented by our community. A number of recommendations for both institutions and individuals were presented to help women succeed in astronomy.

CAASTRO Director Professor Bryan Gaensler reported ways in which CAASTRO is aiming to be family-friendly and gender equitable. Starting with job advertisements, it is policy to offer all positions either full-time or part-time, and of 12 recently appointed CAASTRO research positions, two have been taken up part-time.

At CAASTRO, we also ensure that core meetings take place between 10am–2pm so that people picking up children from school/childcare can attend important meetings. Our Education & Outreach program will involve mentoring for early-career researchers and for girls in science.

Gas in Galaxies: From Cosmic Web to Molecular Cloud | June 2011

This CAASTRO-sponsored meeting was hosted by CAASTRO partner institute Max-Planck Institute for Astrophysics and was held at the beautiful lakeside venue of Kloster Seeon in Germany. The meeting was co-chaired by Guinevere Kauffmann (CAASTRO partner investigator) and Lister Staveley-Smith (CAASTRO Deputy Director). The opening invited talk was given by CAASTRO CI Stuart Wyithe. Many valuable talks were given by other CAASTRO attendees and international researchers.

The meeting also brought together theorists and observers who were able to explore issues surrounding the accretion of gas onto galaxies throughout cosmic time. A consensus among theorists appears to be that, contrary to what was thought until relatively recently, galaxies mostly grow by the smoothly accretion of relatively cold gas, and that the accretion rate determines the history of star formation.

The importance of this accretion process varies with redshift, halo mass and with environment. For the larger halos, accretion, galaxy growth and star formation appear to peak between redshifts of 1 and 3. For lower mass haloes and in low-density regions the cold mode accretion continues until the present. Theorists and simulators have not completely solved all problems. To produce luminosity and mass functions that are compatible with those observed, mechanisms which make accretion less effective for the smallest and the largest galaxies are required. The most popular current mechanisms are feedback by active galactic nuclei and supernovae.

Good overall progress was made towards the goal of better understanding gas processes. Of particular note was the excellent collaboration between theorists, simulators and observers. The complexity of gas accretion and star-formation from gas clouds is such that these groups need to work together to make substantial progress in the future. And of course, there was continued anticipation of new results which will come from the SKA pathfinders. CAASTRO is delighted to thank the Max-Planck Institute for hosting this highly successful meeting.

Novel Radio Telescopes for 21cm Cosmology | June 2011

CAASTRO convened a workshop in Penticton, Canada, to discuss the frontier topic of "Novel Radio Telescopes for 21cm Cosmology".

Through the International Science Linkages program, CAASTRO received $50,000 in funding from the Australian Commonwealth Department of Innovation, Industry, Science and Research to support participation by Australian astronomers and our key US collaborators.

This unique coming-together of international experts took place in June 2011, featuring ten participants from Australia, and 41 researchers from the USA, Canada, India and the Netherlands.

Three CAASTRO Chief Investigators, one Associate Investigator and two Partner Investigators contributed to the scientific program. These presentations and extremely extensive discussion of the theories and techniques that underpin 21cm cosmology resulted in a solid appreciation from all parties as to the full set of experiments taking place.

Of particular note is the emergence of a new project to design and propose a Phased Array Feed (PAF) for installation on the Parkes radio telescope. PAFs are advanced receiver packages that have been developed for CSIRO's Australian SKA Pathfinder (ASKAP) project, directly related to SKA technology development. Part of the science case for such an instrument is to study Baryon Acoustic Oscillations (BAOs), using the signal from hydrogen gas at moderate redshifts.

At the 2011 International SKA Forum in Banff, Canada, the Penticton workshop on 21cm cosmology was highlighted as an excellent example of the collaborative and international approach that Australia is taking in the SKA arena.

Planning for Cosmology | July 2011

The cosmology analysis team in the WiggleZ Dark Energy Survey held a focused workshop on the Gold Coast in July 2011, thanks to CAASTRO support. Our focus was to make significant progress in the set of cosmological measurements we are pursuing using WiggleZ data. Papers that have been submitted for publication in the following months include: the tightest ever limit on the mass of the neutrino from a galaxy redshift survey, based on subtle details in the shape of the galaxy clustering pattern; a new measurement of the "homogeneity" scale of the Universe, an important test of the underlying principles of cosmology; and a determination of the growth rate of structure using flows of galaxies into clusters and superclusters. The WiggleZ Survey has produced new and more accurate measurements of the properties of the "Dark Universe".

2011 Annual Retreat | November 2011

A stellar first year for CAASTRO culminated in our inaugural annual retreat in November 2011, for which 63 members of CAASTRO travelled to Molonglo Observatory near the small country town of Bungendore, NSW. Across the course of two days, participants enjoyed a series of research presentations and interactive sessions, including keynote addresses from Professor Guinevere Kauffmann (Max-Planck Institute for Astrophysics) and from Professor Shri Kulkarni (Caltech).

The retreat provided an opportunity for CAASTRO members to meet - many for the first time - and to learn about the Centre's overall goals. Collaboration is central to CAASTRO's activities, and the retreat enabled all participants to contribute to our plans for 2012 and beyond. A "mentor speed-dating" exercise matched CAASTRO members in areas of common interest and opened dialogue between students, early career researchers and senior scientists across CAASTRO.

EDUCATION & OUTREACH

Greg Madsen provides advice to students at the "Maths and Science EXPOsed" event.
Paul Hancock

The Education & Outreach program of CAASTRO is administered through the Curtin University node and is managed by Chief Investigator Professor Steven Tingay and program coordinator Dr Wiebke Ebeling. With Dr Ebeling's appointment on 1 July 2011, most of the activity in this area took place in the second half of the year. Being CAASTRO's first year, Dr Ebeling's key objectives were to meet the CAASTRO team to develop our commitment to Education & Outreach, to work towards a feeling of unity among members at the six rapidly growing Australian nodes, and to evaluate the most promising approaches to the CAASTRO outreach program.

In the light of the potential for duplication of existing outreach programs in Australian capital cities, we have decided on an outreach strategy that is strongly focussed on reaching diversified demographics through social media.

Throughout 2011, we used Twitter (twitter.com/caastro.arc) for approximately 200 updates to the community about CAASTRO news and events. A second channel to promote CAASTRO is our Facebook page (www.facebook.com/caastro_arc), which not only serves as a forum for more in-depth news items but also as a repository for photos and short videos. In 2011, stories on this page were viewed by over 70,000 users. The number of monthly active users has increased by 400% over the course of the year.

Our main conduits for establishing a strong and discoverable internet presence and to feature our research are our website (www.caastro.org), launched on 12 September 2011, and our YouTube channel (www.youtube.com/user/AstroCentre). Regular updates to the website ensured that CAASTRO was a point of contact for the interested public to get to know us, to read up on major scientific outputs by CAASTRO members, and to turn to CAASTRO as a potential employer. In the first four months of operation, we attracted over 11,000 visitors to the website. With matched numbers of repeat and new visitors to the website, CAASTRO's coverage is increasing steadily, and we are clearly reaching out to an international audience (80% of WWW site hits from overseas in 2011), as well as to the Australian community.

The CAASTRO YouTube channel is instrumental in our outreach strategy: it allows us to communicate our science to a diverse audience, it vastly increases the return from public talks, seminars and press releases, it lets us quickly raise awareness of our research equipment and field sites. We created our YouTube account in late August and had 36 videos uploaded by the end of 2011. These videos include informative material on CAASTRO's all-sky approach (one of which we translated into seven languages), seminar recordings, researcher profiles, facilities that are used in CAASTRO research, and contributions to community engagement. In those four months of YouTube activity, we had over 1500 individual video views (45% from Australia) with the strong indication of increased uptake later in the year.

At the University of Sydney, CAASTRO Senior Research Fellow Dr Greg Madsen is co-funded through the New South Wales State Government's Department of Trade & Investment, Regional Infrastructure & Services to strengthen CAASTRO's involvement in public outreach and school engagement. As part of this agreement, Dr Madsen, together with his CAASTRO colleague, Dr Paul Hancock took part in the public annual event "Maths & Science EXPOsed" which was hosted by the University of Western Sydney on 26 August 2011. Dr Madsen is also making use of the "Connected Classrooms" capability of the NSW Department of Education & Communities. CAASTRO members (local and national) give seminars via video-conferencing technology to reach high school students in both metropolitan and regional areas. Two trial sessions with two consecutive identical seminars each were run in October and November 2011 and were organised in collaboration with Dr Richard Morante (NSW Department of Education & Communities) to fit the NSW curriculum. In 2011, Dr Madsen delivered seminars on the topic of "Einstein and Special Relativity" (to approximately 200 students) which corresponds to the Physics Stage 6 Syllabus. In line with our overall outreach strategy, his seminar was recorded and uploaded to YouTube to be available to viewers beyond the initial audience of NSW students.

CAASTRO's Facebook page

Paul Hancock explains telescope use to students at the "Maths and Science EXPOsed" event in Parramatta.
Credit: Greg Madsen

Group discussion at the first CAASTRO professional training program, held following the Annual Retreat. The facilitator from Econnect Communication (left) is shown with CAASTRO researcher Dr Cathryn Trott.

PROFESSIONAL TRAINING & RESEARCH EDUCATION

Professional training is an important part of every individual's career within CAASTRO: to extend the breadth of their knowledge and skills, to increase competitiveness in grant or job applications, and to work towards research goals. Facilitating access to professional and personal development opportunities for our CAASTRO team members is a significant aspect of the Education & Outreach portfolio. We are especially committed to delivering targeted training and scientific networking to CAASTRO team members.

In conjunction with the 2011 Annual Retreat, we invited our staff and students to participate in a full day "Communication Skills & Media Training" workshop run by Econnect Communication Pty Ltd. Topics covered in this workshop were how to effectively structure and deliver a presentation to a non-technical audience and how to communicate our science in interviews and media releases. Future topics for these professionally facilitated events are "Writing successful grant applications" and "Project Management" with the option of registering for a junior or senior level.

In addition, we aim to encourage our students to establish their scientific networks and collaborations early in their academic careers – given CAASTRO provides such a rich resource in expertise and facilities. By connecting the six node universities via video-conferencing technology, we are developing "Virtual Workshops" with time for student presentations and discussions. An external mentor will usually be present to offer guidance and career advice to supplement their supervision. The first of these "Virtual Workshops" is planned for early 2012 to unite our student community across CAASTRO.

EDUCATE

CAASTRO Director Bryan Gaensler with students Kitty Lo and Sarah Reeves

CAASTRO MENTORING

For the benefit of both our senior and junior team members across CAASTRO, a pilot internal mentoring program has been initiated. We are expecting mentoring relationships to provide our staff and students with a better understanding of the diversity of CAASTRO research projects, to allow them to extend their professional networks, and to provide personal support to all participants. It was agreed by the CAASTRO Executive from the outset that the right pairing of mentor and mentee would be crucial to the success of the program. Individual preferences for a mentoring partner were considered more important than direct science overlap.

We started the program at the first CAASTRO Annual Retreat in November 2011 by guiding the participants through a group exercise analogous to "speed-dating". We divided people up into 15 groups of four CAASTRO members each; we gave them three minutes to get to know each other, after which the groups were re-shuffled. At the end of this exercise all participants were encouraged to nominate their preferred mentor/s and mentee/s, and all responses were collected for evaluation by the CAASTRO Education & Outreach Coordinator.

This immediately led to 45 mentoring pairs where nominations were mutual (23 mentors, i.e. two mentees per mentor on average). As we were fortunate to not only have CAASTRO members from the six Australian node universities attending the Annual Retreat but also from our partner organisations CSIRO and AAO, and from two international partner organisations, the networking and professional development opportunities provided by this mentoring program are substantial.

In the course of 2012, the Chief Operating Officer and the CAASTRO Education & Outreach Coordinator will continue to develop the program. The program will be monitored, and activities will be designed to support the mentoring partners in their relationship. The 2012 Annual Retreat will again include a mentoring session to fine-tune and expand this program.

CAASTRO Annual Retreat at Bungendore in November 2011.

EDUCATION & OUTREACH ACTIVITY PLAN

Fuelled by the positive trends we have been seeing in public awareness of our social media channels, we plan to expand our current collection of YouTube uploads and to also include scientific simulations and a video dictionary for astronomy.

We are completing the collection of Theme profiles and Theme Leader profiles, building on our completed segments on Brian Schmidt and 'The Dark Universe'. These profiles offer insight into the personal paths of our top researchers, give a thorough overview of each research theme and associated research facilities, and provide young people with valuable career advice. For ease of discovery and access, these video clips are sorted into playlists and can also be saved to disk and provided to schools and other interested parties.

Additional video material will come through the continued use of "video press releases", where possible, for new publications. This proved to be extraordinarily well received for our main news story of 2011, on the "Diamond Planet".

Thanks to Dr Greg Madsen at The University of Sydney, our new video-conferencing system will be used extensively in the upcoming "CAASTRO in the Classroom" seminars. For 2012, Dr Madsen is looking to fill five seminar slots per school term with CAASTRO speakers. For the first two school terms, the seminars will be aimed at students in years 7-10 for which the astronomy content is covered by two topics in the New South Wales syllabus: "Newtonian Model of the Solar System" and "Components of the Universe". The schedule for early 2012 includes researchers from all Australian node universities of CAASTRO and from our Partner Investigators at the Australian Astronomical Observatory (AAO).

With Education & Outreach Coordinator Dr Wiebke Ebeling attending two major conferences on science communication and public outreach in early 2012, CAASTRO will experience an important surge in the publicity of our outreach strategy and our national and international connectivity. In particular on the national level, these networking efforts will be directed towards defining outreach opportunities in each of the four Australian capital cities that host CAASTRO nodes. These new ideas will be evaluated alongside feedback received during the node outreach discussion session at our 2011 retreat. These opportunities will be aimed at providing a healthy counter-balance to our social media strategy and at delivering a small number of high impact programs to specific target groups in metropolitan and regional Australia. For example, we are currently collaborating with Musica Viva Australia to provide speakers nationally for pre-concert talks for Tafelmusik's 2012 Galileo Project tour.

On 31 March 2012, CAASTRO will be participating in "Astrofest" in Perth with an information stall to which the public is invited to meet our Western Australian researchers. We are planning on organising a similar event, probably on a bi-annual basis, to take place on the Australian East coast – starting in 2013. To this end, we are also investigating opportunities to attract additional external funding for the CAASTRO Education & Outreach program to further boost our potential to inspire and train the next generation of scientists.

Far left; The MWA Receiver with Professor Steven Tingay (Node Leader, ICRAR - Curtin University; left), Jesse Searls (Managing Director, Poseidon Scientific Instruments; 2nd from left), Derek Carroll (Poseidon Scientific Instruments, 2nd from right), and Mark Waterson (Research Engineer, ICRAR - Curtin University; right). Image credit: ICRAR

Left: Professor Brian Schmidt presents his Nobel Prize Lecture. *Nobel Media AB 2011*

CAASTRO IN THE MEDIA

CAASTRO is very fortunate to have a team of top researchers whose scientific achievements not only attract attention among their peers but also from the local, national and international media. In 2011, we had many occasions to celebrate our researchers' various successes. CAASTRO Director Bryan Gaensler published his first book "Extreme Cosmos" (New South Books, September 2011), charting the hottest, brightest, oldest, biggest, fastest, heaviest and loudest objects in the Universe. This book is yet one more testimony of Gaensler's passion for and skills in communicating science to the public. Associated with the publication of "Extreme Cosmos", Gaensler participated in public discussion panels (Melbourne Writers Festival, 3-4 September 2011, Brisbane Writers Festival, 7-11 September; Adelaide Festival of Ideas, 9 October) and with radio broadcasters, including interviews with ABC Local (30 August 2011), ABC Radio National (13 October 2011), and Radio New Zealand (21 October 2011).

Associated with the official launch of CAASTRO on 12 September 2011, Gaensler had the opportunity to promote our mission through the University of Sydney media office (press releases on 9 and 13 September), an online article in *The Conversation* (12 September) and a live interview on ABC News 24 (13 September). By publishing video material that was collected during the launch festivities, we have also reached out to the broader audience of YouTube users in Australia and the world.

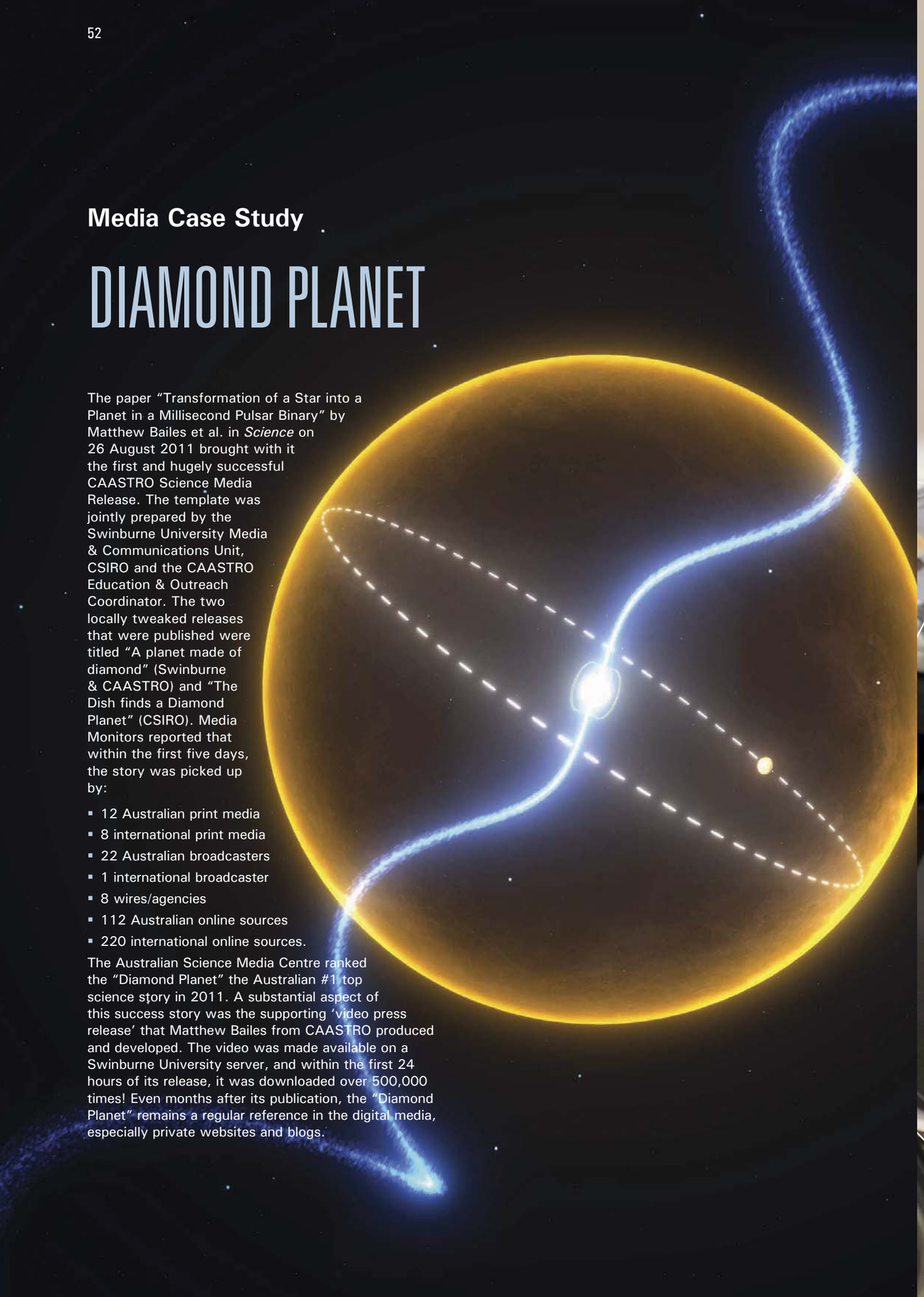
In August 2011, we congratulated CAASTRO's Evolving Universe theme leader Stuart Wyithe for his first major award of the year – a prestigious Australian Laureate Fellowship Wyithe's award and associated achievements were the subject of a feature article in The Australian on 10 August 2011. We were further elated when in October when Wyithe received the 2011 Malcolm McIntosh Prize for Physical Scientist of the Year. This award was covered heavily in all Australian media.

During 2011, our Dynamic Universe theme leader Matthew Bailes created a media sensation with his discovery of the "diamond planet", which he reported in the journal *Science* in August 2011 (see Media Case Study on page 52). Further to his huge scientific success, Bailes was able to gather a large audience of readers with his online articles for The Conversation. His op-ed on "Diamond planets, climate change and the scientific method" (13 September 2011) was ranked #3 top article on The Conversation in 2011, reaching over 70,000 readers.

The single most significant event for our researchers in 2011 was the award of the 2011 Nobel Prize in Physics to Brian Schmidt, Adam Riess and Saul Perlmutter. Not only has this award changed Schmidt's life forever, it has also sent ripples of curiosity, excitement and ambition through the entire Australian public and created valuable opportunities for CAASTRO researchers to communicate the significance of 'Dark Energy'. Some of these communications came from Chief Investigators Jeremy Mould (COSMOS magazine, 6 October) and Warrick Couch (Swinburne Media Centre, 7 December), as well as Associate Investigator Tamara Davis (The Conversation, 10 October; ABC Radio National, 29 October 2011).

Media Case Study

DIAMOND PLANET



The paper "Transformation of a Star into a Planet in a Millisecond Pulsar Binary" by Matthew Bailes et al. in *Science* on 26 August 2011 brought with it the first and hugely successful CAASTRO Science Media Release. The template was jointly prepared by the Swinburne University Media & Communications Unit, CSIRO and the CAASTRO Education & Outreach Coordinator. The two locally tweaked releases that were published were titled "A planet made of diamond" (Swinburne & CAASTRO) and "The Dish finds a Diamond Planet" (CSIRO). Media Monitors reported that within the first five days, the story was picked up by:

- 12 Australian print media
- 8 international print media
- 22 Australian broadcasters
- 1 international broadcaster
- 8 wires/agencies
- 112 Australian online sources
- 220 international online sources.

The Australian Science Media Centre ranked the "Diamond Planet" the Australian #1 top science story in 2011. A substantial aspect of this success story was the supporting 'video press release' that Matthew Bailes from CAASTRO produced and developed. The video was made available on a Swinburne University server, and within the first 24 hours of its release, it was downloaded over 500,000 times! Even months after its publication, the "Diamond Planet" remains a regular reference in the digital media, especially private websites and blogs.

CAASTRO LOCATIONS

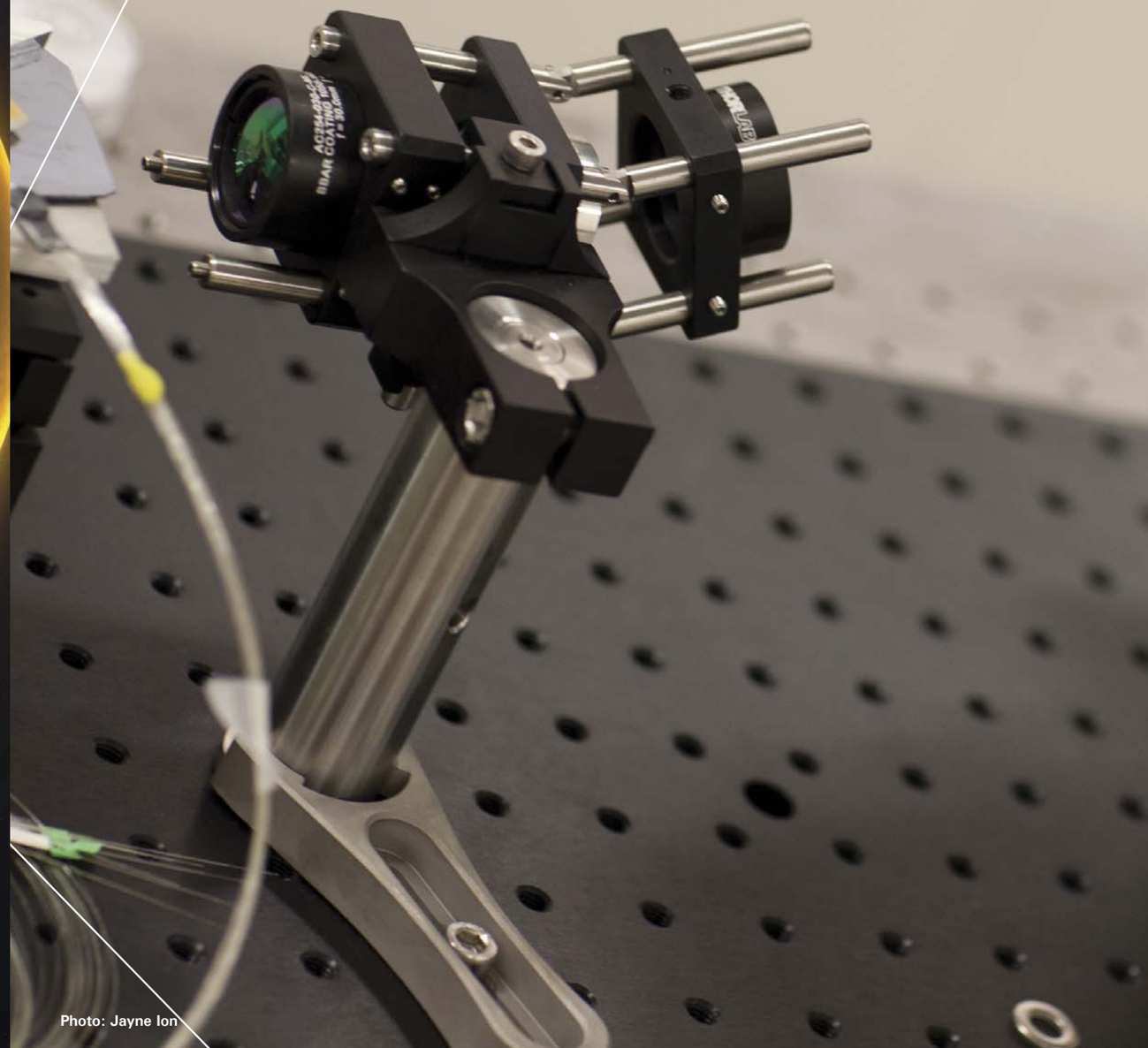


Photo: Jayne Ion

THE UNIVERSITY OF SYDNEY

CAASTRO AT THE UNIVERSITY OF SYDNEY

CAASTRO University of Sydney team members

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 (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).
- 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, Farrell, Gaensler, 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, Murphy, Thakkar)

2011 saw an explosive growth of activity at Sydney in all these topics – we started with three Chief Investigators (Bryan Gaensler, Elaine Sadler and Scott Croom) and one Associate Investigator (Tara Murphy), but by year's end, the Sydney CAASTRO team had grown to more than 20 members, including 8 postdocs and 3 PhD students.

Amongst our research highlights for the year were:

- A collaboration with CAASTRO theorists at the University of Melbourne, in which we showed that rotation measure synthesis can be used to recover the signature of cosmic hydrogen reionisation in the presence of contamination by polarised foregrounds (see pp10-11). We applied the rotation measure synthesis technique to the Stokes I component of a synthetic data cube containing Galactic foreground emission, instrumental polarisation leakage and redshifted 21-cm emission by neutral hydrogen from the Epoch of Reionisation. This produced an effective Stokes I Faraday dispersion function for each line of sight, from which instrumental polarization leakage was able to be fitted and subtracted. Our results show that it is possible to recover the signature of reionisation in its late stages by way of the 21-cm power spectrum, as well as through tomographic imaging of ionised cavities in the intergalactic medium.
- Development of a new technique for stacking radio interferometry visibilities to form a deep composite image, which we then applied it to observations of transient phenomena. We applied "visibility stacking" to 46 archival Very Large Array observations of nearby type Ia supernovae. This new approach has provided an upper limit on the type Ia ensemble peak radio luminosity which is 5-10 times lower than any previous measurement. Our measurements allow the double degenerate scenario for type Ia supernovae, but rule out intermediate- and high-mass companions in the single degenerate scenario. In the era of time domain astronomy, techniques such as visibility stacking will be important in extracting the maximum amount of information from observations of populations of short-lived events.
- An innovative new approach to identification and parameterisation of 21cm hydrogen absorption produced by distant galaxies that occur in the line of sight towards strong radio continuum sources. We have developed a method for simultaneously finding and fitting 21cm absorption lines in radio data by using "multi-nested sampling", a Bayesian Monte Carlo algorithm. We have tested the method on a simulated ASKAP data cube, and have shown this approach to be reliable at detecting absorption lines in low signal-to-noise data without the need to smooth or alter the data. By estimating the local Bayesian evidence statistic, our work provides a quantitative criterion for assigning significance to a detection and for selecting between competing analytical line-profile models.

The Sydney team were also very active in outreach and education activities throughout 2011 – audiences for our public lectures and talks ranged from primary school children all the way through to TEDxSydney. We also spent much of 2011 developing "CAASTRO in the Classroom", a video-conferencing initiative that we will roll out to high schools across NSW in 2012. And to cap it off, the CAASTRO Director Bryan Gaensler had an especially busy year, with the publication of his first book, "Extreme Cosmos", with associated appearances at the Brisbane and Melbourne Writers' Festivals.

We were especially proud to have hosted CAASTRO's first completed PhD! Keith Bannister, co-supervised by Bryan Gaensler, Tara Murphy and Tim Cornwell (CSIRO), completed a very fine thesis on "Radio Surveys: Transients & Techniques", and subsequently took up a prestigious Bolton Fellowship at CSIRO Astronomy & Space Science. Keith will continue his association with CAASTRO as an affiliate member.

As the headquarters for CAASTRO, Sydney University quickly built up a diligent and efficient administrative unit, consisting of Kate Gunn (Chief Operating Officer), Debra Gooley (finance), Joanne Daniels (executive support) and Susan Parker (events & communications). The team at "mission control" organised the spectacular CAASTRO launch at Sydney Observatory in September 2011, quickly followed up by a very successful CAASTRO Retreat in Bungendore in November 2011. Work is already underway for the 2012 CAASTRO Retreat, as well as organisation of scientific workshops hosted by CAASTRO for 2012 and 2013.

Professor Bryan Gaensler

CAASTRO Director
Themes: Dynamic, Evolving

In 2011, Gaensler worked on algorithms for polarisation calibration of Epoch of Reionisation data, and on techniques for identifying and characterising transient sources in radio data. In 2012, he plans to begin applying his polarisation algorithms to real data, and to pursue early science on transients and variables with the MWA.

Professor Elaine Sadler

CAASTRO Chief Investigator
Theme: Evolving

In 2011, Sadler has been working with CAASTRO Associate James Allison and PhD student Sarah Reeves to develop new techniques for identifying and studying 21cm HI absorption lines in wide-band radio data. In 2012 they will be using these techniques to analyse data from the Australia Telescope Compact Array (ATCA) in preparation for the forthcoming ASKAP FLASH survey, a blind all-sky HI absorption-line survey at redshift $0 < z < 1$.

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 Australian Astronomical Observatory (AAO). 2011 was a spectacular success, with the commissioning of the Sydney-AAO Multi-object Integral field spectrograph (SAMI) on the Anglo-Australian Telescope. In 2012 he will be focusing on carrying out the first survey observations with this instrument, which will provide a new view on the physical processes that govern galaxy formation and evolution.

Professor Anne Green

CAASTRO Affiliate
Themes: Dynamic, Evolving

Green continues with the development of the SKAMP project and expects to begin commissioning in 2012. In a project to understand massive star formation and to eventually produce a model to feed

into galaxy evolution simulations, a study of the Carina Nebula is being undertaken with the Australia Telescope Compact Array in 2012.

Dr Julia Bryant

CAASTRO Research Fellow
Theme: Evolving

Bryant is working on a galaxy survey using the new SAMI instrument on the AAT, having been part of the instrument team that developed, built and commissioned SAMI. Bryant will be a core part of the SAMI galaxy survey and use the spatially-resolved spectra of a thousand galaxies to disentangle the roles of the environment, AGN processes and star bursts in the evolution of galaxies.

Dr Steve Curran

CAASTRO Research Fellow
Theme: Evolving

Curran is preparing for the First Large Absorption Survey in HI, to be undertaken with the Australian SKA Pathfinder, in the search for the cool, star-forming material in the early Universe. In 2011, in conjunction with Matt Whiting at CASS, he found that placing a powerful quasar in a galaxy of gas will ionise all of the neutral material. In 2012 he hopes to further develop his hypothesis that the optical properties of the galaxies absorbing radiation from more distant quasars can be used to convert the 21-cm absorption strength into a total hydrogen column density.

Dr Greg Madsen

CAASTRO Senior Research Fellow
Theme: Dynamic

Madsen's focus in 2011 was development of the SKA Molonglo Pathfinder (SKAMP) as a tool for discovering radio transients. In 2012, he will be exploring large historical archives of optical surveys to find large amplitude optical variables and transients. Madsen has actively contributed to CAASTRO's education and outreach activities, and has led the establishment of the 'CAASTRO in the Classroom' program.

Dr Elizabeth Mahony

CAASTRO Research Fellow
Theme: Evolving

Mahony worked on a short-term CAASTRO project, "The optical spectra and redshift distribution of AT20G radio sources", which was co-sponsored by CSIRO. The aim of this short project was to analyse new optical spectra (mainly from the 8m Gemini telescope) of southern radio sources from the Australia Telescope (AT20G) survey.

Dr James Allison

CAASTRO Affiliate
Theme: Evolving

Allison is a member of the ASKAP First Large Absorption Survey in HI (FLASH) - a survey science project that will be used to probe the distribution and evolution of neutral Hydrogen to high redshifts. In 2011 Allison developed a technique for line finding in FLASH data and conducted observations of HI absorption with the Australia Telescope Compact Array. Plans for 2012 include continued preparation for the ASKAP-FLASH project using existing facilities and archival HI data.

Dr Sean Farrell

CAASTRO Affiliate
Theme: Dynamic

Farrell's specialisation is X-ray astronomy, focussing on the study of accreting compact objects (i.e. black holes, neutron stars and white dwarfs), in particular the search for intermediate mass black holes. As a CAASTRO affiliate, he will be providing support through his expertise in X-ray astronomy to various CAASTRO activities.

Dr Martin Bell

CAASTRO Postdoctoral Researcher
Theme: Dynamic

Since joining CAASTRO, Bell has been working with data from the Murchison Wide Field Array (MWA). In 2012 he hopes to publish some of this work, and to continue exploring the dynamic radio sky with wide field instruments.

Dr Paul Hancock

CAASTRO Affiliate
Themes: Dynamic, Evolving

Hancock has developed a process called visibility stacking that allows the use of multiple radio observations to more accurately characterise a population of sources. He has demonstrated this technique on observations of Type Ia supernovae and will be applying the same technique to observations of gamma ray burst afterglows. He has also developed a new algorithm called Aegean for identifying radio sources and is currently expanding its functionality.

Mr Jay Banyer

CAASTRO Professional Staff
Theme: Dynamic

As a software engineer, Banyer has been developing the VAST transient pipeline prototype. With further enhancements this software will be used to help commission and perform transient searches with ASKAP BETA and WMA. He has also been developing SKAMP software including the ingest pipeline and control system, and assisted with exhaustive testing of the SKAMP correlator's X engine.

Mr Duncan Campbell-Wilson

CAASTRO Affiliate
Theme: Dynamic

As the Manager of the Molonglo Radio Observatory, Campbell-Wilson has been involved with radio astronomy /astrophysics, engineering (electronic, electrical and mechanical), radio telescope construction and development for over 25 years. In 2011, the site and staff hosted the CAASTRO Annual Retreat, as well as providing advice on the detection of transient radio sources. Campbell-Wilson will be enabling the operation of SKAMP 2 in 2012, and providing data to CAASTRO for various data analysis projects.

Mr Darshan Thakkar

CAASTRO Professional Staff
Theme: Dynamic

As a digital engineer, Thakar is involved in 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.

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 2012, Murphy plans to conduct extensive radio follow-up of extreme GRB events, carry out several new surveys for transients, and get the first results from the MWA 32T observations which will provide one of the best low frequency blind surveys for transients conducted so far.

Keith Bannister

CAASTRO Affiliate (CAASTRO postgraduate)
Theme: Dynamic

Bannister's research focuses on the search for astronomical radio transients, using new techniques and upcoming surveys. He is currently following up a range of candidate transients from the Molonglo telescope and will be helping with ASKAP science commissioning this year.

Ms Kitty Lo

CAASTRO postgraduate student
Theme: Dynamic

Lo's PhD project is on radio transients which fits into CAASTRO's Dynamic Universe research theme. She is working on automatic classification algorithms for the Variable and Slow Transients (VAST) survey on ASKAP.

Ms Sarah Reeves

CAASTRO postgraduate student
Theme: Evolving

In 2011 Reeves' focus was on obtaining new radio observations of nearby galaxies. These observations will improve our understanding of galaxies in our local universe, as well as forming a crucial part of preparation for the First Large Absorption Survey in HI (FLASH), which aims to study galaxy evolution in the distant universe. In 2012 Sarah will continue analysis of these observations and begin work on constructing the FLASH target database.

Ms Kate Gunn

CAASTRO Chief Operating Officer

Gunn is the Chief Operating Officer of CAASTRO. A start-up specialist with a wealth of business and University experience, Kate has been well placed to establish the necessary foundations for CAASTRO to grow and achieve its goals. Kate 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 coordination and management of ARC Centre of Excellence KPI and financial reporting, and other associated reports for CAASTRO to support the achievement of the Centre's goals and objectives.

Ms Jo Daniels

CAASTRO Executive Assistant

Daniels provides executive assistance to the CAASTRO Director and other CAASTRO staff.

Ms Susan Parker

CAASTRO Events and Communications Officer

Parker has a passion for organising events and enjoys communicating with a range of stakeholders. In 2011 Parker very successfully organised the CAASTRO Launch and the first CAASTRO Annual Retreat.

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieve International Excellence

CAASTRO AT THE UNIVERSITY OF WESTERN AUSTRALIA (UWA)

CAASTRO UWA team members

The UWA node of CAASTRO is collocated with the International Centre of Radio Astronomy Research (ICRAR) at the Ken and Julie Michael Building on Fairway in Perth. Node activities are spread across the dynamic, evolving and dark themes although emphasis will shift to the latter two themes as ASKAP swings into action. 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 work alongside CAASTRO researchers at other nodes and researchers at a large number of Australian and overseas institutions. The goals of Wallaby and Dingo, and other science being undertaken at the node, are to understand the evolution of galaxies and to probe the distribution of matter in the Universe using world-class radio, optical and computational facilities.

Lister and Martin are "foundation" members of CAASTRO at the UWA node. However, they were soon joined by Associate Investigator Chris Power, postdoctoral scientist Se-Heon Oh, programmer Shin Kee Chung, and administrative officer Katie Lau. CAASTRO researchers at UWA are currently spending considerable time developing new algorithms, techniques and simulations in preparation for the upcoming surveys. Recent technical advances have included:

- Improved spectrometers using power-efficient advanced graphics processors.
- High-resolution dark matter and semi-analytic simulations of the Wallaby and Dingo volumes.
- Development of algorithms to decompose noisy, multi-component velocity fields in spatially resolved galaxies.

Other highlights have been:

- An innovative study of the homogeneity of the Universe using WiggleZ data. This study gives an accurate upper scale for the presence of inhomogeneities in the Universe, and has allowed verification of the predictions of the standard lambda cold dark matter model of the Universe.
- Analysis of all available Parkes data taken as part of the new CAASTRO 2MASS Tully-Fisher (2MTF) project to measure cosmic flows in the local Universe. The 2MTF survey will make the most accurate measurements of the cosmic flow field in the nearby Universe prior to the forthcoming Wallaby/SkyMapper surveys.
- Successful mid-term reviews of the Wallaby and Dingo projects were conducted, with substantial progress being made by team members in many areas, including automated velocity-field parameterisation and source-finding.

One of the strengths of CAASTRO, much appreciated by UWA node members, is the mix of observational, theoretical and computational research that CAASTRO brings to the research table. Collaborative activity with other CAASTRO nodes, and with ICRAR researchers, is extremely good. CAASTRO researchers at the UWA node have regular coffee meetings to discuss progress and events, and have Perth-area meetings with researchers from the Curtin node every few months.

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

- Development of the Survey Simulations Pipeline (SSimPl), which will provide the framework for creating synthetic galaxy surveys for next generation telescopes such as ASKAP and the SKA.
- Initial template verification and distance measurements for the 2MTF survey.
- Wallaby and SkyMapper peculiar velocity simulations.
- Deployment of GPU spectrometer.
- Development of a kinematic pipeline for Wallaby and Dingo.

Professor Lister Staveley-Smith

CAASTRO Deputy Director
Themes: Evolving and 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 on various pre-ASKAP surveys such as the re-vamped 2MTF survey, and worked with the MWA project scientist to develop a tile configuration strategy for MWA.

Associate Professor Martin Meyer

CAASTRO Associate Investigator
Themes: Evolving

Meyer's leadership role in the DINGO survey has seen him contribute to new projects to stack HI data at moderate redshifts with existing telescopes such as Parkes. A new study of the cosmic HI density and the global Tully-Fisher relation is underway with PhD student Jacinta Delhaize.

Associate Professor Chris Power

CAASTRO Associate Investigator
Themes: Evolving and Dark

Power is an expert in dark matter and galaxy formation who has been using a combination of analytical modelling and supercomputer simulations to study problems ranging from the growth of super-massive black holes in galaxies to the structure of dark matter haloes. Chris was the co-organiser of the highly-successful Wallaby simfest which preceded the CAASTRO retreat and worked with other Wallaby and Dingo investigators during the year to develop a simulation roadmap.

Dr Se-Heon Oh

CAASTRO Postdoctoral Researcher
Theme: Evolving

Oh commenced in May 2011 from his previous position at UCT. He made an immediate impact in the area of velocity field characterisation in galaxies, which is one of the more challenging areas in dealing with ASKAP HI data. He continued his work on the dynamics of galaxies.

Mr Shin Kee Chung

CAASTRO Postdoctoral Researcher
Theme: Dynamic

Chung is a software engineer who commenced in April 2011 to work on GPU spectrometers. He spent his time developing a general CPU/GPU FFT and polyphase filterbank, and has also spent time working with the BIGHORNS project led by Randall Wayth in the Evolving Universe theme.

Ms Katie Lau

CAASTRO Administrator

Lau uses her extensive professional experience in University administration to provide 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.

Ms Morag Scrimgeour

CAASTRO Postgraduate Student
Theme: Dark

Scrimgeour enrolled at UWA in 2010 to work on dark matter and cosmology. She is supervised by Lister Staveley-Smith, Peter Quinn (UWA) and Tamara Davis at the University of Queensland, but also works with other CAASTRO investigators Brian Schmidt and Chris Blake. Her work in 2011 included a new study of the homogeneity of the Universe using WiggleZ redshift data.

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 researchers at the AAO, CSIRO and Monash University.

THE UNIVERSITY OF MELBOURNE

CAASTRO AT THE UNIVERSITY OF MELBOURNE

CAASTRO University of Melbourne team members

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, Riding).
- Numerical simulation of the evolution of early galaxies and their interaction with the high redshift intergalactic gas (Wyithe, Tescari, Bolton, Kim, 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).

2011 saw a rapid ramp up of activity at Melbourne in all these areas – the CAASTRO team now numbers more than 12, including 4 postdocs and 3 PhD students.

Amongst our research highlights for the year were:

- We showed that the dependence of Lyα absorption on environment leads to significant non-gravitational features in the redshift space power spectrum of Lyα selected galaxies (see p16). As a result, power-spectrum measurements could be used as a new probe to study the astrophysics of the galaxy-intergalactic medium (IGM) connection, and to measure the properties of outflows from star-forming galaxies. Applying the modified redshift space power spectrum to a Lyα survey with parameters corresponding to the planned Hobby-Eberly Telescope Dark Energy Experiment (HETDEX), our study found that the dependence of observed Lyα flux on velocity gradient and ionizing background may compromise the ability of Lyα selected galaxy redshift surveys to constrain cosmology using information from the full power spectrum. (Wyithe)
- Surveys of Ly-alpha emitters indicate that tens of sources should be visible within an observing field, whereas in the vicinity of bright quasars none are observed. The observed difference indicates that the quasar environment has a significant influence on the observed density of Ly-alpha emitters. To quantify this effect we have constructed a semi-analytic model to simulate the effect of a luminous quasar on nearby Ly-alpha emitters. We find the null detection implies that the minimum virial mass of the Ly-alpha emitter host halos is 100 billion solar masses. This indicates that the intense UV emission of the quasar may be suppressing the star formation in nearby galaxies. Our study illustrates that low redshift quasar environments may serve as a surrogate for studying the radiative suppression of galaxy formation during the epoch of reionization. (Bruns, Wyithe)
- High-redshift measurements of the baryonic acoustic oscillation (BAO) scale from large Lyα forest surveys represent the next frontier of dark energy studies. We constructed a model for producing fast, large-volume simulations of the Lyα forest for this purpose. Utilizing a calibrated semi-analytic approach, we developed a method to run very large simulations in 1 Gpc^3 volumes which fully resolve the Jeans scale in less than a day on a desktop PC using a graphics processing unit enabled version of our code (see p17). The Lyα forest spectra extracted from our semi-analytical simulations are in excellent agreement with those obtained from a fully hydrodynamical reference simulation. We applied our model to simulations of the Baryon Oscillation Spectroscopic Survey, and also used our simulations to provide simple power-law expressions for estimating the fractional error on the BAO scale on varying the signal-to-noise ratio and the number density of background sources. (Greig, Bolton, Wyithe)
- Using the 6dF galaxy redshift survey, we found that stellar population trends not just with velocity dispersion and fundamental plane residual, but with radius and surface brightness as well. The most remarkable finding is that the stellar population parameters vary through and across the plane, but show no variation at all along the plane, roughly corresponding to the parameter `luminosity density'. A galaxy's position along this vector was being closely tied to its merger history, such that early-type galaxies with lower luminosity density are more likely to have undergone major mergers. This conclusion is reinforced by an examination of simulations, which show clear trends of merger history with this luminosity density. (Magoulas, Webster)
- In 2011 we successfully installed and tested the MWA Real-Time System (RTS) on the real-time computer nodes that are temporarily housed at ICRAR, where it is being used to process data from the 32-tile prototype array. The RTS is a wide-field calibration and imaging pipeline that will run on-site at the Murchison Radio-Astronomy Observatory. More recently, the parallel RTS development effort used to process data from the prototype array has been incorporated back into the master code base, with the merged software soon to be made available as the first official RTS release. The software is regularly used to image data from site, both long integrations and wide surveys, and has been used to make the first detection of polarization from a radio galaxy with the MWA. (Mitchel, Webster, Pindor)
- During 2011 we have initiated a new state-of-the-art program performing cosmological hydrodynamical simulations with which to better understand the interplay between galaxies and intergalactic medium (IGM) from redshift $z \sim 2$ to the epoch of reionization 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. Our theoretical program will be used to understand the latest observations in collaboration with CAASTRO member Emma Ryan Webber at Swinburne. (Tescari, Bolton, Kim, Wyithe)
- We presented the most up-to-date thermal constraints on the reionization of hydrogen by stellar sources. 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 inhomogenous reionization, to establish new constraints on the redshift at which hydrogen reionization completed. The near-zone temperature measurements constrain the redshift by which hydrogen reionization was complete to be $z > 7.9$. This implies that future temperature measurements around other high redshift quasars will significantly increase the power of this technique, enabling these results to be tightened and generalised. (Bolton, Wyithe)

During 2011 members of the Melbourne node developed an innovative program "Telescopes in Schools" that has purchased ten 12-inch (30-cm) telescopes with a range of accessories to be loaned to underprivileged schools across Melbourne. This project will train 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 2011 – from public lectures through to our work experience program.

The team at Melbourne is very ably assisted in their work by administrative officer Kim Dorrell who has very efficiently managed node affairs including organization of events including the MWA collaboration meeting.

Professor Stuart Wyithe

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

In 2011, Wyithe worked on studies of the effect that fluctuations in transmission of Ly-alpha from through the intergalactic medium would have on studies of clustering. In 2012, he plans to work on incorporating simulations into this clustering work.

Professor Rachel Webster

CAASTRO Chief Investigator
Theme: Evolving

During 2011 Webster concentrated her efforts towards preparations for the MWA via studies of foreground populations at the Giant Metrewave Radio Telescope (GMRT). Over the next year she plans to work with the MWA team on preparations for the MWA Epoch of Reionisation experiment.

Dr Jamie Bolton

CAASTRO Associate Investigator
Themes: Evolving, Dark

During 2011 Bolton worked with PhD student Brad Greig on developing simulations to calculate the effect of absorption on the clustering of Ly-alpha sources. In 2012, Bolton will contribute to the development of CAASTRO's high redshift super-computing simulation program.

Dr Edoardo Tescari

CAASTRO Fellow
Theme: Evolving

After arriving towards the end of 2011 Tescari has already initiated a program of simulation to study the relation between metals in the intergalactic medium and high redshift galaxies, which was awarded 600 thousand hours of cpu time at NCI. During 2012 Tescari will lead the running of an analysis of this simulation program.

Dr Daniel Mitchell

CAASTRO Senior Research Fellow
Theme: Evolving

During 2011 Mitchell led the Real Time System (RTS) development effort. He spent most of his time incorporating features of the two RTS code branches into a single RTS release, analysing data from the prototype array in preparation for the upcoming MWA commissioning activities, and testing the RTS on the real-time compute cluster. In 2012 Mitchell will lead RTS commissioning activities and further develop the software for use in post processing and deep EoR imaging.

Mr Brad Greig

CAASTRO PhD student
Theme: Dark

During 2011 Greig published a paper with a novel approach to calculating the clustering signal in the Ly-alpha forest with application to dark energy surveys. In 2012 his focus will shift to calculation of how intergalactic absorption effects the clustering of Ly-alpha emitting galaxies.

Mr Loren Bruns

CAASTRO PhD student
Theme: Evolving

In 2011 Bruns published his paper describing the effect that a quasar has on the observed properties of nearby Ly-alpha selected galaxies. In 2012 Bruns will focus on completion of his PhD thesis.

Ms Christina Magoulas

CASTRO PhD student
Theme: Evolving

In 2011 Magoulas has been working on the properties of elliptical galaxies and the fundamental plane using the 6dF galaxy redshift survey. In 2012 Magoulas will focus on completion of her PhD thesis.

Mrs Jennifer Riding

CAASTRO PhD student
Theme: Evolving

During 2011 Riding began her PhD in low-frequency radio astronomy, and has concentrated on analysing challenging data from the Giant Metrewave Radio Telescope. During 2012, Riding will help to develop and test the RTS, in particular the calibration system, be involved in other MWA science commissioning activities, and assist with the planning and acquisition of the initial EoR dataset.

Dr Han-Seek Kim

CAASTRO Affiliate
Theme: Evolving

During 2011 Kim developed a new code that incorporates semi-numerical study of reionisation structure into the semi-analytic code Galform using the Millennium simulation, and used this to study the effect of supernova feedback on the 21cm power spectrum from reionisation. In 2012, Kim will extend this work to incorporate the Millennium-II simulation.

Dr Bart Pindor

CAASTRO Affiliate
Theme: Evolving

During 2011 Pindor has been working on porting the RTS ionospheric correction algorithms to run on GPUs as well as preparing to run the RTS and MAPS simulator on the gSTAR facility. In the coming year, Pindor will also be working on creating and commissioning the interface between the RTS and the MWA Monitor & Control system whose development is being led by the University of Washington, as well as continuing to develop and validate the ionospheric correction package.

Ms Kim Dorrell

CAASTRO Executive Officer

Dorrell brings a broad range of research-oriented administrative experience to The University of Melbourne node from prior roles at the Centre for Eye Research Australia, the Australian Twin Registry, the Centre for MEGA Epidemiology, and CSIRO's division of Mathematical and Information Sciences.

SWINBURNE UNIVERSITY OF TECHNOLOGY

CAASTRO AT SWINBURNE UNIVERSITY OF TECHNOLOGY

The Swinburne CAASTRO node is located at the Hawthorn campus within the Centre for Astrophysics and Supercomputing (CAS). CAS is one of the biggest astronomy research centres in Australia. It also operates a significant supercomputing facility (including a new state-of-the-art GPU-based machine, gSTAR), a Virtual Reality Theatre, and concentrates on problems in astrophysics that benefit from these unique resources.

Swinburne researchers are primarily engaged in the "Dark Universe" and "Dynamic Universe" theme areas of CAASTRO, with Prof Matthew Bailes being the theme leader for the latter. The key areas of activity in each area are as follows:

The Dynamic Universe theme

Development of new radio frequency interference (RFI) mitigation techniques for pulsar and transient surveys that use the Parkes 64m radio dish.

Development of a new transient detection pipeline for Parkes that will run in real time, by exploiting the computational power and energy efficiency of graphics processing units (GPUs).

Development of a transient detection pipeline that will function in a commensal mode with other observing programs at the Giant Meter Wave Radio Telescope (GMRT) in India.

During 2011, sizeable research groups were assembled in these two areas, built around Chief Investigators Couch and Mould, and Associate Investigator Blake in the Dark Universe area, and Chief Investigator Bailes in the Dynamic Universe area. Three postdocs (Kazin, Koda and Lagattuta) were employed for the former, and two postdocs (Bhat and Kocz) plus a software engineer (Jameson) were employed for the latter. A total of 4 PhD students plus an outstanding visiting Honours student from New Zealand (who will return to do his PhD at Swinburne on CAASTRO science) also worked across the two theme areas. A new CAASTRO administrator (Mansfield) was also recruited.

The Dark Universe theme

Realising significant improvements in the WiggleZ Dark Energy Survey measurements of the baryon acoustic oscillation (BAO) peak through a process called "density-field reconstruction", which removes some of the effects of the non-linear growth of structure.

Extending the scope of the cosmological measurements obtained from the WiggleZ Survey dataset, in particular by combining with other datasets.

Modelling how forthcoming peculiar velocity surveys will place new constraints on the understanding of dark matter and dark energy.

Undertaking the optical and radio measurements for the major peculiar velocity survey that will carried out with SkyMapper and ASKAP in the south, and Pan-STARRS and the Westerbork Synthesis Telescope in the north.

Amongst out research highlights for the year were:

- Publication of important pathfinder work for the peculiar velocity surveys planned with SkyMapper and ASKAP, including significant improvements to the Tully-Fisher method for determining distances, and modelling of systematic effects in the galaxy samples that will be used.
- The discovery of a "diamond planet" – a very low-mass companion to a millisecond pulsar – which attracted huge media coverage world-wide. (See pp13 & 52)
- Publication of a paper describing the digital signal processing software developed by van Straten and Bailes. This software is the primary analysis tool employed in sophisticated pulsar instrumentation at the Parkes radio telescope and other premiere observatories around the world. It implements an advanced radio frequency interference mitigation algorithm based on spectral kurtosis, which is an important part of our research and development on instrumentation for real-time fast transient detection.
- Publication of the first results of the High Time Resolution Universe Transient Survey. Initial processing of a small fraction of the survey has produced 11 discoveries, all of which are sparsely emitting neutron stars. The completion of the survey analysis is predicted to double the known population of rotating radio transients.
- Two very successful WiggleZ Dark Energy Survey meetings were held – one a workshop to progress the cosmology science, held on the Gold Coast, and the other being a meeting of the full team at Swinburne to review the science outcomes of the project and plan future research activities.

CAASTRO Swinburne University of Technology Team members

Professor Matthew Bailes

CAASTRO Chief Investigator and Dynamic Universe Theme Leader
Theme: Dynamic

In 2011, Bailes and his pulsar survey team discovered a very low-mass companion to a millisecond pulsar that was dubbed the "Diamond Planet" by the world's media. In 2012, he will participate in the RFI mitigation and transient detection pipeline activities for Parkes and GMRT.

Professor Warrick Couch

CAASTRO Chief Investigator
Theme: Dark

In 2011, Couch played a major management role in the WiggleZ Dark Energy Survey and oversaw the recruitment of new CAASTRO-funded personnel in the Dark Universe area. He will continue to play this role and be involved in the WiggleZ science being pursued at Swinburne.

Professor Jeremy Mould

CAASTRO Chief Investigator
Theme: Dark

Mould is leading the optical and radio observational programs that will be undertaken for a major peculiar velocity survey of the local universe in order to map the underlying dark matter and constrain cosmological models. He undertook important preparation activities for this survey in 2011, and will continue these in 2012.

A/Prof Chris Blake

CAASTRO Associate Investigator
Theme: Dark

Blake led much of the WiggleZ Dark Energy Survey science in 2011, first-authoring the land-mark cosmology papers that were published. In 2012, he will continue to further progress the completion and publication of key scientific results from the WiggleZ Survey, as well as supervise CAASTRO postdocs Kazin and Koda, who are working in the Dark Universe area.

Dr. Emma Ryan-Weber

CAASTRO Associate Investigator
Theme: Evolving

Ryan-Weber works in the Evolving Universe theme area, with strong collaborative links to Wyithe and his team at the University of Melbourne. In 2011, she spent a large fraction of the year on maternity leave. Upon her return, she resumed her research on mapping the distribution of galaxies around metal absorbers close to the epoch of reionisation. In 2012 (and beyond) she plans to follow-up of newly discovered high redshift quasars from SkyMapper to investigate the intergalactic medium.

Dr. Willem van Straten

CAASTRO Affiliate
Theme: Dynamic

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 2011, he was involved in the High Time Resolution Universe and Parkes Pulsar Timing Array projects, both based at the Parkes Observatory in New South Wales. He also contributed to the planning and design of pulsar instrumentation for the Square Kilometre Array Pathfinders in Australia (ASKAP) and South Africa (MeerKAT) and to the development and support of pulsar data analysis software for the low frequency arrays in The Netherlands (LOFAR) and Australia (MWA). He will continue these activities in 2012.

Professor Karl Glazebrook

CAASTRO Affiliate
Themes: Dark, Evolving

Glazebrook has, for the last two years, been leading an effort to develop a large scientific collaboration between Australian astronomers and the U.S. focused Dark Energy Survey (DES). This involves wide-field imaging of 4000 deg2 of the southern sky in 5 filters, and has a wide-field spectroscopy capability (AAT). This activity naturally falls within CAASTRO's projects and is very valuable and synergistic with ASKAP/MWA/GAMA. The activity to commence an OZDES wide-field SNe survey for dark energy has already started with time on the AAT for a pilot. Glazebrook is also pursuing deep galaxy evolution survey work which naturally complements CAASTRO's wide-field surveys.

Dr. Ramesh Bhat

CAASTRO Postdoctoral Researcher
Theme: Dynamic

Bhat works in the area of observational pulsar astronomy and the transient radio universe. In 2011, his research focus included binary-pulsar tests of the theories of gravity, investigation of transient phenomena such as giant radio pulses and the use of pulsar measurements to probe the ISM. He also contributed to the technical and science demonstration experiments related to high time resolution astronomy in the SKA-era. In 2012, he will continue these activities, as well as take part in developing new capabilities for the GMRT in the areas of pulsars and transients.

Dr Jonathon Kocz

CAASTRO Postdoctoral Researcher
Theme: Dynamic

In 2011, Kocz worked on the the development of new instrumentation for pulsar observations, and the development and application of radio frequency interference excision algorithms to pulsar data. He will continue to work on these projects in 2012 until his departure in April, when he will take up a new position at Harvard.

Dr Eyal Kazin

CAASTRO Postdoctoral Researcher
Theme: Dark

Kazin's research focus is significantly improving the WiggleZ survey measurements of the baryon acoustic oscillation (BAO) peak through a process called "density-field reconstruction", which removes some of the effects of the non-linear growth of structure. The improvements from applying this analysis technique are potentially equivalent to acquiring another 200 nights of telescope data! Kazin is also involved in the Baryon Oscillation Spectroscopic Survey (BOSS), which is extending the WiggleZ Survey results to larger volumes.

Dr Jun Koda

CAASTRO Postdoctoral Researcher
Theme: Dark

Koda's expertise is in modelling how forthcoming peculiar velocity surveys will place new constraints on models of dark matter and dark energy. Despite the large efforts being put into such observational programs, there is still a lot of theoretical uncertainty about what aspect of the cosmological model they will best constrain. Koda's forecasts will provide a toolbox for the analysis of the eventual dataset, and in some cases will greatly assist survey design.

Dr David Lagattuta

CAASTRO Postdoctoral Researcher
Theme: Dark

Lagattuta is highly experienced with optical imaging (with applications in gravitational lensing and galaxy formation/evolution) and has responsibility for the optical photometry measurements from SkyMapper that will be required for the SkyMapper/ASKAP peculiar velocity survey.

Mr Andrew Jameson

CAASTRO Software Engineer
Theme: Dynamic

Jameson brings skills in software development, systems administration, high performance computing and scientific visualisation. In CAASTRO, he will work closely with Swinburne's Pulsar Astronomy group developing hardware and software instrumentation systems for use at the Parkes Radio Telescope. His contributions will be in the areas of data acquisition, real-time processing, interference excision and data archival.

Ms Carly Mansfield

CAASTRO Administrator

Carly Mansfield joined the CAASTRO Swinburne node in September 2011, having previously worked in academic administration, including three years working at the Centre for Adult Education in Melbourne, and two years working for the Institute of Biomedical Engineering (IBME) at Oxford University (UK) assisting the administration and IT teams.

Australian National University

CAASTRO AT THE AUSTRALIAN NATIONAL UNIVERSITY (ANU)

CAASTRO ANU Team members

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 disastrous 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. These projects include the SkyMapper Telescope and its widefield camera at the ANU's Siding Spring Observatory and radio astronomy receivers for the Murchison Widefield Array (MWA).

The ANU is the prime driver of CAASTRO's Dark Universe theme through the leadership of the Dark Energy discoverer, Nobel Prize winner Professor Brian Schmidt. Schmidt's ground breaking research relied on surveys to discover and characterise distant supernovae, which are among the most energetic of events in the cosmos and which are prime examples of the types of dynamic/transient events at the core of the Dynamic Universe theme. These are important targets for the wide-field surveys and all-sky monitoring to be conducted with Skymapper.

The MWA radio telescope will be an important contributor to the science of both the Dynamic and Evolving Universe themes, as it has an exceptionally wide field of view of the heavens, making it efficient at finding and following transient events. The wide field nature of the design also increases the efficiency of the MWA (and future telescopes that build on the MWA's design) at building a statistically significant picture of the evolution of the first structures (stars and galaxies) in the early Universe.

The SkyMapper Telescope moved closer to regular operations, with an unexpected problem that required disassembling of the Imaging Camera in Canberra, fixed over the last 3 months of the year. During 2011, the telescope was shown to have achieved its performance goals with respect to optical image quality, scattered light performance, connectivity, CCD read out time, and automated scheduling. The telescope has a resonance on its secondary mirror, which remains an outstanding issue, along with 4 (out of 64) noisy channels in the array. These issues should be addressed in the first part of 2012 so that regular operations can be commenced.

A team at LPNHE in France led by CAASTRO partner investigator Reynald Pain, has nearly completed a precision calibration instrument, "SkyDice", which will be commissioned on SkyMapper in mid-2012. This instrument will enable the Skymapper telescope and imager to be calibrated to an unprecedented level of precision, a requirement of its precise supernova survey. The development of a supernova subtraction pipeline was started in mid-2011 and will be completed by mid-2012. This will enable regular discoveries and operations of supernovae to take place.

Radio astronomers at ANU have been key contributors to the development of the Murchison Widefield Array (MWA), whose goal is the development of instrumentation and analysis tools for observing the Epoch of Reionisation, a period more than 13 billion years ago when the first stars ignited as the first galaxies formed. Based on the technologies tested with the 32 Antenna Tile prototype work, the MWA will expand and enter routine operation in the course of 2012.

Prof 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 2012, 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 will be highlighting his and CAASTRO's work on Dark Energy with more than 20 planned lectures in 2012.

Prof 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 2011 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 2012, he will continue his research on radio techniques, with emphasis on the characterisation and suppression of the effects of radio frequency interference.

Dr Stuart Sim

CAASTRO Associate Investigator
Theme: Dynamic

Sim's research focuses on the theory of supernova explosions. In 2011, he worked on developing new models for faint thermonuclear explosions of low-mass white dwarf stars. These models will help interpret observations taken as part of the next generation of astrophysical transient surveys, such as will be carried out with the SkyMapper telescope. In 2012 he plans to work on radiative transfer simulations for white dwarf mergers, with particular focus on late-phases (e.g. around 1 year post-explosion). Accurate modelling of late-time spectra is one of the most promising means to observationally distinguish explosion models for thermonuclear supernovae.

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.

Dr Fang Yuan

CAASTRO Research Staff
Theme: Dynamic

Yuan is responsible for the development of the SkyMapper transient search pipeline. By the end of 2011, a prototype pipeline was in place. She also started a project to investigate the nature of peculiar calcium-rich sub-luminous supernovae through studies of their explosion sites. In 2012, Dr Yuan will help to maintain and refine the transient search pipeline on real-time SkyMapper observations. She will also assist with the classification and follow-up of SkyMapper transients. Her main science interests are the calcium-rich events and super-luminous supernovae, including the probable pair-instability explosions.

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 a gamma-ray burst, which is associated with a supernova. In the next year Rapoport plans to create our own hydro models and 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.

Mr Jonghwan Rhee

CAASTRO 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, using 21-cm HI emission line stacking techniques. In 2011 he carried out and began analysing radio observations with the GMRT and optical spectroscopic observations with the Anglo-Australian and Multi-Mirror Telescopes. In 2012, he plans to complete his analysis of these data and publish the results.

Mr Benjamin McKinley

CAASTRO PhD Student
Theme: Evolving

McKinley began his PhD in 2011 and has been focussed on studying radio galaxies with the Murchison Widefield Array (MWA). In 2012 Mr McKinley hopes to be part of the science commissioning of this exiting new instrument, which will probe the Universe at low radio frequencies. His focus will be on uncovering new information about the structure and evolution of Centaurus A, the closest radio galaxy to us in the Universe, and helping to develop techniques to process and analyse data from the MWA.

Mrs Denise Sturgess

CAASTRO Administrator

Sturgess is the CAASTRO Node Administrator at the Australian National University. Sturgess is an experience administrator, having worked for a number of years in the business community, including the Canberra Business Council.

Curtin University

CAASTRO AT CURTIN UNIVERSITY

CAASTRO Curtin University Team members

Astrophysics research at Curtin University is a relatively new enterprise. Home of CAASTRO at Curtin University is the Curtin Institute of Radio Astronomy (CIRA) that was established in 2007. CIRA is led by two foundation Professors, Steven Tingay (Physics) and Peter Hall (Engineering). Curtin's investment in establishing CIRA is motivated by Australia's involvement in the Square Kilometre Array (SKA) project and the possibility that the SKA could be located in Western Australia.

The purpose of 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. Curtin University is also the lead institution in the $50 million Murchison Widefield Array project, an SKA precursor telescope being 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 entered into the final stage of construction, and will be complete in November 2012 and ready for science in early 2013.

CAASTRO sits alongside, interacting closely with, and complements activities of the International Centre for Radio Astronomy Research (ICRAR), an equal joint venture between Curtin University and The University of Western Australia, in which Professor Tingay acts as Deputy Director. The Curtin CAASTRO team is led by Professor Tingay, CAASTRO Chief Investigator and CAASTRO Executive member with carriage of Education & Outreach to bring CAASTRO's scientific output to the public, using astronomy to advance the public's awareness of science and the scientific process.

In the first year of CAASTRO, four new hires were made to support CAASTRO programs. Two postdoctoral research staff started in 2011: Dr Cathryn Trott (Dynamic Universe theme), Dr Steven Tremblay (Dynamic Universe theme). The third initial hire was the CAASTRO Education and Outreach Coordinator, Dr Wiebke Ebeling.

Dr Jean-Pierre Macquart (Dynamic Universe theme) and Dr Randall Wayth (Evolving Universe theme) are CAASTRO Associate Investigators, and Mr Mehran Mossammaparast (Evolving Universe theme) is a postgraduate student (MSc). Ms Tanya Jones (administrative coordinator) and Ms Tina Sallis (finance) provide administrative support to the Curtin CAASTRO team and to visitors from interstate and overseas.

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 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 the next major advance 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. The 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 year 2012 will see "first light" for the system with data collection field trips scheduled for the second half of the year. *(Tingay, Wayth, Sokolowski, Mossammaparast, Tremblay)*

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. 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 10^3 – 10^6 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 UV 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).(Tingay, Macquart, Trott, Tremblay; cross-node collaboration with Kitty Lo, University of Sydney).

Dr Tremblay's involvement in both research themes is the development of techniques, utilising both hardware and software, to mitigate the effects of terrestrial frequency interference to better enable detection of the inherently weak signals being searched for.

Highlights and achievements of the Curtin University node in 2011 include organising and hosting the first CAASTRO Advisory Committee face-to-face meeting in early August 2011 and the Executive meeting in mid September 2011. Major progress has been made by the administrative team in 2011 in compiling and returning required information, such as financial and non-financial Key Performance Indicators, in a fast and effective manner.

With the Curtin node in charge of CAASTRO's Education & Outreach strategy, CAASTRO's 2011 press releases, public talks, University Open Day participation, video productions and media interactions were coordinated across the six nodes through Curtin. CAASTRO's social media presence aims to take all-sky astronomy to the world via YouTube, Facebook and other portals. This has been very successful thus far and promises to give CAASTRO wide reach over the life of the CAASTRO programs.

2011 CAASTRO research at the Curtin node was successfully published or submitted for publication in peer-reviewed journals and was also the topic of numerous presentations at in-house colloquia, the CAASTRO Annual Retreat, data analysis workshops, the ATNF Science Day, and international conferences (e.g. IAU Symposium 285). The Curtin team is particularly proud of Dr Cathryn Trott's cross-disciplinary work with geologists for the analysis of opal growth rates and her and her co-authors's paper, describing a very novel approach to radio astronomy data processing, which will be the first in a series of papers that describe new ways to extract transient signals from large datasets. This is a new and innovative way to think about our data, which will be required for the larger and larger datasets we collect.

Professor Steven Tingay

CAASTRO Chief Investigator,
Education & Outreach Theme Leader
Themes: Evolving Universe, Dynamic

In 2011 as a member of the CAASTRO Executive, Tingay put a lot of time into developing the CAASTRO science programs, establishing the Centre and the Curtin University node, as well as going through the process of hiring the first set of CAASTRO employees at Curtin. He is now looking forward to working on the science and education aspects of CAASTRO after the establishment phase. 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).

Dr Jean-Pierre Macquart

CAASTRO Associate Investigator
Theme: Dynamic

Throughout 2011, Macquart investigated optimal ways of detecting transients with next generation radio arrays, such as ASKAP, the MWA and the SKA. The aim of the work was to relate the rate of detected transients to the underlying physical luminosity distribution and distance distribution of a putative population of transients. The work folds in the effects of interstellar scattering, which can moderate the Signal-to-Noise of any impulsive transients, especially at low transients. More broadly, he has also been considering means to optimise the real-time detection of fast transients using interferometers, in a manner which allows one to search the entire primary beam field of view of the telescope across a range of dispersion measures, but localises the transient with a synthesised beamwidth.

Dr Randall Wayth

CAASTRO Associate Investigator
Theme: Evolving

Wayth is the Project Manager of the CAASTRO-supported EoR Global Signal project (codename "Bighorns") that was launched in 2011. The project

has made good progress towards developing a highly sensitive calibrated radiometer and data processing system for the Global Signal experiment, with CAASTRO MSC student Mehran Mossammaparast playing a major role in the work. The Bighorns system will be deployed in field trials and on several data collection field trips to remote Western Australia where the sky is free of man-made interference.

Dr Steven Tremblay
CAASTRO Postdoctoral Fellow
Theme: Dynamic

Having started in September, most of Tremblay's 2011 activities involved getting acquainted with CAASTRO projects and people. In 2012, he will implement a fast transient data collection mode within the MWA and progress the EoR Global Signal experiment to the point where radio frequency interference can be removed from the data. He also plans on continuing to work with data from the Long Wavelength Array which he helped getting operational as part of his PhD.

Dr Cathryn Trott
CAASTRO Postdoctoral Fellow
Theme: Dynamic

In 2011, Trott worked on a framework for a visibility-based source detector and detection performance for a novel fast transients detector/de-dispersion system. She also investigated fundamental source estimation limits with next-generation radio interferometers and application to limits on estimation of the 21cm EoR signal. In cross-disciplinary research with Curtin University geologists, she provided the mathematical analysis for modelling the growth of opal samples (geochronology). Her plans for 2012 are to define practical algorithms and apply techniques to real datasets (MWA 128T and ASKAP commissioning data), as well as to extend visibility-based source detection to include flags for variable sources, with a view to producing a slow transient pipeline, independent of the traditional image-based pipelines. She will explore techniques for classifying slow transients, with particular attention to the cadence and frequency of blind radio surveys and the effect on two-dimensional power spectra in the 21cm EoR signal. Collaborations with geologists are ongoing for dating of Apollo lunar breccia samples.

Dr Wiebke Ebeling
CAASTRO Education & Outreach Coordinator

Since July 2011, Ebeling has been successfully tracking CAASTRO's coverage in the media and using this information to maintain our social media channels and the new website. She has taken on the responsibility of communicating CAASTRO related and relevant science news, events, and award announcements to a rapidly growing Australian and international audience. She has also been coordinating public outreach, professional development, mentoring, and school engagement activities across the six CAASTRO nodes. In 2012, the CAASTRO Education & Outreach program will unfurl its full breadth of activities with a balance between social media and targeted local programs. Dr Ebeling will further spread the public awareness of CAASTRO on a national and international scale by presenting at two major conferences in early 2012.

Mr Mehran Mossammaparast
CAASTRO Postgraduate Student (MSc)
Theme: Evolving

Since the second half of 2011, Mossammaparast has been involved in designing and testing the analogue components for the EoR Global Signal (Bighorns) receiver in the laboratory. Work will be continuing on the first prototype testing of the completed front-end and gain modules. This will then be followed by integrating the receiver gain module, data acquisition unit, and master controller unit into a portable rack cabinet. The prototype antenna, the receiver front-end module, and the rack back-end will then complete the signal path for the initial field deployment.

Ms Tanya Jones
Administrative Coordinator

Since April 2011, Jones has responsibility of providing administrative support and leadership to all CAASTRO team members and to newly commencing staff at Curtin University. A further aspect of her role is the reporting of the non-financial CAASTRO Key Performance Indicators for the Curtin team. In 2012, she will continue to assist CAASTRO members at the Curtin node, as well as interstate and international visitors and coordinate the administrative work of CAASTRO, ICRAR, and CIRA.

Ms Tina Sallis
CAASTRO Finance Officer

In 2011, Sallis had the responsibility of providing financial support and advice to the CAASTRO team members based at Curtin University. There has also been the responsibility of producing the financial data for reconciliation against the CAASTRO Budget. In 2012, the financial support and financial administration will continue with emphasis on providing the CAASTRO Curtin node staff with valid financial information to ensure that they can carry out their research activities.

CAASTRO PARTNERS

CAASTRO's Partner Organisations in 2011 and corresponding Partner Investigators were:

Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Assoc Prof Brian Boyle
Dr Robert Braun
Professor Ray Norris

Australian Astronomical Observatory (AAO)
Professor Matthew Colless
Associate Professor Andrew Hopkins

Max-Planck Institute for Astrophysics, Germany
Professor Guinevere Kauffmann

California Institute of Technology, USA
Professor Shri Kulkarni

University of Oxford, UK
Professor Steve Rawlings

Durham University, UK
Professor Carlos Frenk

Max-Planck Institute for Radio Astronomy, Germany
Professor Michael Kramer

University of Arizona,USA
Professor Xiaohui Fan

University of Toronto, Canada
Associate Professor Ue-Li Pen

Laboratoire de Physique Nucléaire et de Hautes Energies, France
Dr Reynald Pain

Raman Research Institute, India
Professor Ravi Subrahmanyan

UNITE

SCIENTIFIC LINKAGES

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.

Dr Chris Lidman

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.

Commonwealth Scientific and Industrial Research Organisation

Dr Brian Boyle

Dr Boyle is CSIRO's SKA Director. His primary research interests are in the fields of quasars, active galaxies and cosmology, and he is currently involved in the Australia Telescope Large Area Survey (ATLAS). The CSIRO is a world leader in science and engineering associated with radio astronomy, and is leading Australian efforts on the Square Kilometre Array. The CSIRO offers outstanding computational services, several of the world's most powerful radio telescopes, and a world-class engineering team.

Dr Robert Braun

Dr Braun is Chief Scientist for CSIRO Astronomy and Space Science. Braun's scientific contributions to CAASTRO will be 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.

The University of Queensland

Dr Tamara Davis

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.

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 Kauffmann

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.

CAASTRO COLLABORATIONS

CAASTRO staff have been involved in a number of additional collaborations with institutions both in Australia and internationally during the course of 2011, including the following.

The 6dFGS Peculiar Velocity Field

Institutions: Australian Astronomical Observatory, University of Melbourne, Swinburne University of Technology, University College London (United Kingdom), Monash University, Durham University (United Kingdom), University of Western Kentucky (United States), Spitzer Science Center (California Institute of Technology, United States)

This collaboration has carried out a trial run of the CAASTRO dark matter program using 6dF Redshift Survey data instead of ASKAP data. Preliminary results will be presented in early 2012. We have derived a value of the cosmological bias parameter. We also compute a dipole in the velocity field after correction for the velocities due to galaxies.

EBootes collaboration

Institutions: Monash University, Jet Propulsion Laboratory, University of California at Berkeley, National Radio Astronomy Observatory, National Optical Astronomy Observatory, Ohio State University, Swinburne University of Technology, University of Leiden, Observatoire de Paris-Meudon

This collaboration is working on evolution of radio galaxies. The survey field is the Bootes field whose optical coverage is the NOAO Deep Wide Field. Deeper radio data will be obtained in 2012 with the EVLA.

KDUST collaboration

Institutions: University of Chicago, Texas A&M University, University of California at Berkeley, University of New South Wales, Swinburne University of Technology, National Institute of AstrOptics (China), Jet Propulsion Laboratory

This collaboration is working on the next generation 2 micron sky survey. The telescope is the Kunlun Dark Universe Survey Telescope planned for construction and operation at Dome A in Antarctica. A Phase A study was carried out at the AAO under the auspices of the PILOT (Pathfinder for an International Large Optical Telescope) project.

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.

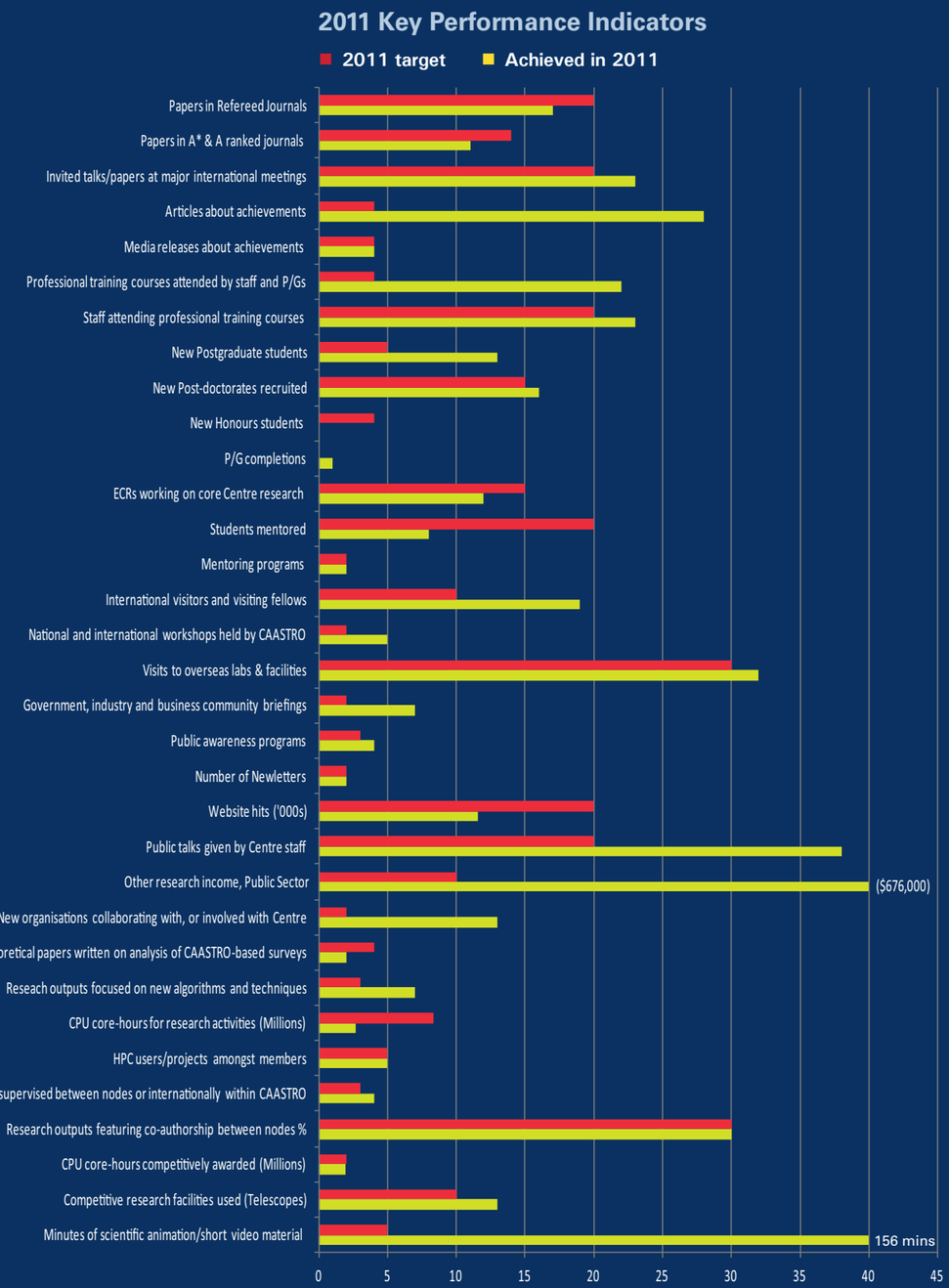
Large Synoptic Survey Telescope

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

CAASTRO and The Large Synoptic Survey Telescope (LSST) have entered into negotiations on how Australian astronomers can contribute to the operational support of LSST which is planned to begin full scientific operations in the 2020 timeframe.

CAASTRO commenced operations on 1 April 2011, and these Key Performance Indicators represent our activities for the last 9 months of the year. The CAASTRO website was launched at the time of the launch of the Centre on 12 September 2011, so the number of website hits reflects a 4 month period only.

KPI DASHBOARD



FINANCIAL STATEMENTS

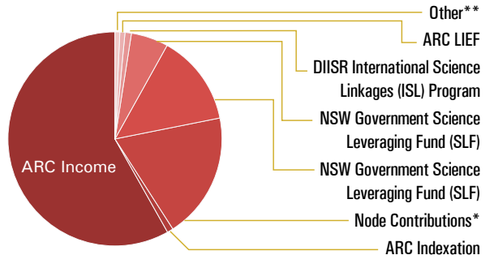
CAASTRO FINANCIAL REPORT JANUARY - DECEMBER 2011

2011 INCOME		2012 ESTIMATED INCOME	
Carry Forward	$-	Carry Forward (ARC & Node Contributions)	$2,293,910
ARC Income	$3,000,000	Carry Forward (Other income)	$636,642
ARC Indexation	$47,431	ARC Income	$2,800,000
Node Contributions	$912,272	ARC Indexation	$84,000
NSW Government Science Leveraging Fund (SLF phase 1)	$710,000	Node Contributions*	$1,004,146
NSW Government Science Leveraging Fund (SLF phase 2)	$290,000		
DIISR International Science Linkages (ISL) Program	$50,000		
ARC LIEF (UWA)	$60,000		
Other**	$37,294	Other**	$-
TOTAL INCOME	**$5,106,997**	**TOTAL ESTIMATED INCOME**	**$6,818,698**

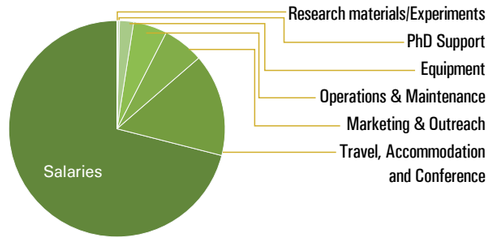
*Includes payment by ANU for 2011, $69,539
**Other income includes interest from NSW SLF Grants and Scholarship Contribution

2011 EXPENDITURE (from unaudited ARC Grant only)		2012 ESTIMATED EXPENDITURE	
Salaries	$1,467,096	Salaries	$3,371,968
Travel, Accommodation and Conferences	$363,516	Travel, Accommodation and Conferences	$671,500
Marketing & Outreach	$124,914	Marketing & Outreach	$80,000
Operations & Maintenance	$103,342	Operations & Maintenance	$50,400
Equipment	$102,993	Equipment	$167,007
PhD Support	$5,709	PhD Suppport	$180,000
Research materials/Experiments	$8,874	Research materials/Experiments	$168,121
TOTAL EXPENDITURE	**$2,176,445**	**TOTAL 2012 ESTIMATED EXPENDITURE**	**$4,688,996**
BALANCE	**$2,930,552**	**ESTIMATED BALANCE**	**$2,129,702**

2011 INCOME BY SOURCE



2011 EXPENDITURE



CAASTRO IN-KIND CONTRIBUTIONS 2011

University of Sydney	$717,528
University of Western Australia	$164,257
University of Melbourne	$81,568
Swinburne University of Technology	$913,066
Australian National University	$778,610
Curtin University	$349,097
CSIRO	$327,210
Australian Astronomical Observatory	$790,620
Max Planck Institute for Radio Astronomy	$112,410
California Institute of Technology	$134,673
The University of Oxford	$51,170
Durham University	$202,108
Max-Planck Institute for Astrophysics	$74,737
The University of Arizona	$60,000
The University of Toronto	$41,300
Laboratoire de Physique Nucléaire et de Hautes Energies	$246,000
Other in-kind income (University of Queensland)	$12,139
TOTAL	**$5,056,493**

CAASTRO 2011 ADDITIONAL INCOME

OTHER GRANTS	
NSW Government Science Leveraging Fund (SLF)	$290,000
Department of Innovation, Industry, Science and Research, International Science Linkages (ISL) Program	$50,000
ARC LIEF (University of Western Australia)	$60,000
Science and Industry Endowment Fund (SIEF) John Stocker Postdoctoral Fellowship	$276,000
TOTAL	**$676,000**

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)

Additional Chief Investigators

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

Partner Investigators

14. Andrew Hopkins
15. Brian Boyle


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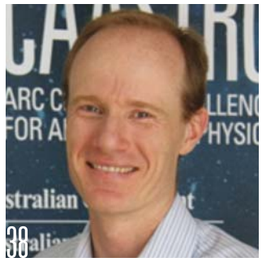
16. Ray Norris
17. Carlos Frenk
18. Guinevere Kauffmann
19. Matthew Colless
20. Michael Kramer
21. Robert Braun
22. Shri Kulkarni
23. Steve Rawlings
24. Ue-Li Pen
25. Xiaohui Fan
26. Reynald Pain
27. Ravi Subrahmanyan

Associate Investigators

28. Chris Blake
29. Jamie Bolton
30. Tamara Davis



31. Chris Lidman
32. JP Macquart
33. Martin Meyer
34. Tara Murphy
35. Chris Power
36. Emma Ryan-Weber
37. Stuart Sim
38. Randall Wayth

CAASTRO Research Staff

39. Martin Bell
40. Ramesh Bhat
41. Julia Bryant
42. Shin Kee Chung
43. Stephen Curran
44. Andrew Jameson
45. Eyal Kazin

46. Jonathon Kocz
47. Jun Koda
48. David Lagattuta
49. Greg Madsen
50. Elizabeth Mahony
51. Daniel Mitchell
52. Se-Heon Oh
53. Edoardo Tescari
54. Steven Tremblay
55. Cath Trott
56. Fang Yuan

CAASTRO Professional Staff

57. Jay Banyer
58. Kim Dorrell (Executive Officer, U. Melbourne)
59. Wiebke Ebeling (Education & Outreach Coordinator)
60. Debra Gooley (Finance Officer)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61. **Susan Parker (Events and Communications Officer)**
62. **Tanya Jones (Administrative Coordinator, Curtin U.)**
63. **Katie Lau (Administrative Officer, UWA)**
64. **Carly Mansfield (Administrator, Swinburne U.)**
65. **Denise Sturgess (Administration Officer, ANU)**
66. **Darshan Thakkar**

CAASTRO Affiliates

67. **James Allison**
68. **Keith Bannister**
69. **Duncan Campbell-Wilson**
70. **Sean Farrell**
71. **Karl Glazebrook**
72. **Anne Green**
73. **Paul Hancock**
74. **Hansik Kim**
75. **Philip Lah**


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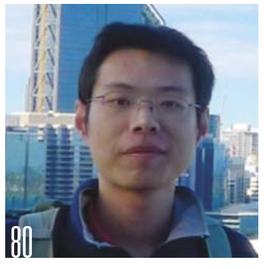
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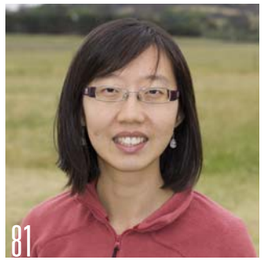
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76. **Bart Pindor**
77. **Willem van Straten**

CAASTRO Students

78. **Loren Bruns, Jr.**
79. **Bradley Greig**
80. **Tao Hong**
81. **Kitty Lo**
82. **Ben McKinley**
83. **Christina Magoulas**
84. **Mehran Mossammaparast**
85. **Sharon Rapoport**
86. **Sarah Reeves**
87. **Jennifer Riding**
88. **Jonghwan Rhee**
89. **Morag Scrimgeour**

Not pictured

90. **Joanne Daniels (Executive Assistant to Director & COO)**
91. **Tina Sallis (Finance Manager, Curtin U.)**


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PROFESSOR STEVE RAWLINGS

1961-2012

In January 2012, as this Annual Report was being written, the CAASTRO team was shocked by the sudden passing of our valued partner investigator, collaborator and friend, Professor Steve Rawlings. Below we reproduce a brief obituary for Steve, written by his colleagues in the Department of Physics at the University of Oxford.

Steve Rawlings was a great man and a great astronomer. He did his PhD at the Cavendish Laboratory in Cambridge in the late 1980s. There he worked on giant radio galaxies and quasars, using a variety of astronomical techniques to analyse their radio and optical properties and to determine their distances from the Earth.

After a Research Fellowship at St John's College Cambridge, Steve moved to Oxford on a research council Advanced Fellowship. Increasingly, Steve became interested in the high redshift universe and greatly enjoyed, and succeeded in, discovering more-and-more distant radio galaxies. His interests in cosmology grew, and diversified into other wavebands: X-rays, sub-mm and infra-red. Steve was a prolific user of two telescopes in Hawaii the James Clerk Maxwell Telescope and the UK Infrared Telescope and made major contributions to our understanding of distant active galaxies, their gas and dust contents, and especially their evolution across cosmic time.

Steve brought considerable energy to yet-fainter surveys of objects in the distant universe in the sub-mm and infra-red. He also enjoyed observing at the Giant Metrewave Radio Telescope in India and his passion for very low frequency radio observations produced considerable momentum towards the ambitious, next-generation radio telescopes such as LoFAR and the Square Kilometre Array (SKA). His immense efforts varied from persuasion at political levels, to simulations of what might be detected by differently designed telescopes, to studies of how to meet the enormous computational challenges the SKA would bring. He was motivated by the scientific goals of these next-generation telescopes: measuring the distribution of hydrogen in the Universe since the Big Bang, discerning the nature of the Dark Energy said to pervade the Universe, measuring the accretion history of the Universe, and the influence of radio galaxies on the formation of structures such as galaxies and clusters. He also contributed greatly to studies of the Sunyaev-Zeldovich effect: the imprint on the Cosmic Microwave Background of hot electrons captured in the deep potential wells of clusters of galaxies. Steve Rawlings' creativity in these and many other areas greatly enriched the field, and will have an enduring influence on it.

Steve was not only an excellent scientist but also a dedicated tutor and mentor - he was central to much of what happens in Oxford Astrophysics through his role as Head of Astrophysics from 2005 to 2010 and in many other ways. Steve was inclusive and supportive and engendered those values in all who interacted with him. He was also great fun: many former students and colleagues around the world will recall playing football or cricket with him. Steve's personality and values permeate our activities. He will be very sadly missed by all.

THE UNIVERSITY OF SYDNEY

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieve International Excellence

THE UNIVERSITY OF MELBOURNE

SWINBURNE UNIVERSITY OF TECHNOLOGY

Australian National University

Curtin University

Australian Government
Australian Research Council

NSW GOVERNMENT Trade & Investment

CAASTRO
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