

# SKA PhD Scholarship Scheme

## 2019 Projects

**Program Contact:** Lister Staveley-Smith ([lister.staveley-smith@uwa.edu.au](mailto:lister.staveley-smith@uwa.edu.au)) or Robert Shen ([robert.shen@astronomyaustralia.org.au](mailto:robert.shen@astronomyaustralia.org.au))

### Project List

Below is a list of the projects available in 2019. Project abstracts are available further down.

- Neutral hydrogen in the distant Universe: new insights from 21cm HI absorption (University of Sydney)
- Connecting gas content to the location of star formation (University of Sydney)
- Magnetic fields in the Magellanic system (Australian National University)
- High-redshift QSOs in the Southern sky (Australian National University)
- Determination of radio spectrum, Stokes parameters and rotation measure from magnetohydrodynamic simulations of high redshift radio galaxies (Australian National University)
- Delivering the goods - Data-intensive SKA-scale astronomy (University of Western Australia)
- Exploiting the next-generation radio surveys with spectral stacking (University of Western Australia)
- Galaxy formation and evolution (University of Western Australia)
- Epoch of Re-ionisation: Foreground removal (University of Melbourne)
- Astronomical knowledge discovery beyond the petascale (Swinburne University of Technology)
- An up-close view of extremely gas rich, turbulent disk galaxies (Swinburne University of Technology)
- How do galaxies continue to form stars? (Swinburne University of Technology)
- General-purpose GPU-based radio interferometry instrumentation for high time resolution studies of pulsars and Fast Radio Bursts (Swinburne University of Technology)
- Finding Strong Gravitational Lenses in the High-Resolution imaging era (Swinburne University of Technology)
- Open clusters: a key for Galactic Archeology (Swinburne University of Technology)
- Imaging with an array of omnidirectional dipoles (Curtin University)
- Finding exotic pulsars using the FAST and the First SKA-Low Precursor Telescope (Curtin University)
- Understanding the Radio Emission from Star Forming Galaxies in the SKA Era (Curtin University)
- An environmental census of black hole activity and star formation (University of Tasmania)
- The HII Region Population in the Milky Way (University of Tasmania)
- Dense Gas across the Milky Way (University of Tasmania)

# University of Sydney

**Primary contact:** Elaine Sadler (elaine.sadler@sydney.edu.au)

**Supervisor:** Elaine Sadler (University of Sydney/CSIRO)

**Project title:** Neutral hydrogen in the distant Universe: new insights from 21cm HI absorption

**Project Abstract:** One of the main goals of the SKA is to trace the neutral phase of hydrogen, the most abundant element in the Universe, out to high redshift and connect this to the formation and evolution of galaxies across cosmic time. Observations of the 21cm line of neutral hydrogen (HI), seen in absorption against strong radio continuum sources, can provide us with unique information about the amount, distribution and physical state of neutral atomic gas in galaxies at different cosmic epochs, and the relationship of this gas to cosmic star formation.

In this project, you will use the Australian SKA Pathfinder (ASKAP) radio telescope to search for redshifted HI absorption lines along sightlines towards distant radio quasars. By combining the ASKAP observations with theoretical simulations, as well as searching for the intervening galaxies responsible for the 21cm absorption, the aim is to find out what kinds of galaxies contain the bulk of the neutral gas at redshifts of  $0.5 < z < 1$  (a lookback time of 5-7 Gyr, or about half the age of the Universe).

**Supervisor:** Scott Croom

**Project title:** Connecting gas content to the location of star formation

**Project Abstract:** The fundamental fuel for star formation is hydrogen gas that accretes onto galaxies, cools and forms stars. How and where the accretion of gas is modulated, and how this influences star formation is poorly understood. In this project we will aim to combine radio observations that measure the gas content in local galaxies (via 21cm emission line measurements) with spatially resolved maps of star formation from the new SAMI Galaxy Survey (<http://sami-survey.org/>). This survey, that contains thousands of galaxies across all environments (from voids to dense clusters) gives us the opportunity to understand how a galaxy's environment influences gas accretion onto it, and in turn how that modulates star formation.

**More information on Sydney:**

[www.sydney.edu.au](http://www.sydney.edu.au) (The University of Sydney)

[www.sydney.com.au](http://www.sydney.com.au)

[www.cityofsydney.nsw.gov.au/learn/about-sydney/tourist-information](http://www.cityofsydney.nsw.gov.au/learn/about-sydney/tourist-information)

# Australian National University

**Primary contact:** Naomi McClure-Griffiths (naomi.mclure-griffiths@anu.edu.au)

**Supervisor:** Naomi McClure-Griffiths

**Project title:** Magnetic fields in the Magellanic system

**Project abstract:** Magnetic fields affect the evolution of the Universe on all scales from the Sun to galaxy clusters. They provide nearly as much energy into the interstellar medium as gas motions or thermal heating, are essential to star formation and contribute enormously to the total pressure of interstellar gas. And yet, we know very little about the origin of magnetic fields within galaxies or indeed the nature of magnetised gas in galaxies. This project will work with new radio interferometric data from the Australia Telescope Compact Array of polarized extragalactic sources to probe the magnetised, ionised medium throughout the nearest galaxies, the Large and Small Magellanic Clouds. This project will carry on into the Australian SKA Pathfinder Polarization survey of the Universe's Magnetism (POSSUM) and will involve collaboration with Dr Ann Mao at the Max Planck Institute for Radioastronomy in Bonn, Germany and Prof Bryan Gaensler at the University of Toronto, Canada.

**Supervisor:** Christian Wolf

**Project title:** High-redshift QSOs in the Southern sky

**Project abstract:** The SkyMapper Southern Survey covers the entire Southern hemisphere in six bands to 22 mag. Based on its first data release, two bright QSOs at redshift  $\sim 5$  were already found. In this project, we want to identify the complete list of luminous high-redshift QSOs, measure their black-hole masses, and determine their radio properties. This will prepare the ground for multi-wavelength follow-up including the Australian SKA Pathfinders and in the SKA era.

**Supervisor:** Geoff Bicknell

**Project title:** Determination of radio spectrum, Stokes parameters and rotation measure from magnetohydrodynamic simulations of high redshift radio galaxies

**Project abstract:** The interaction of relativistic jets with the interstellar medium of evolving galaxies is a form of black hole feedback, which is believed to have an important influence on the evolution of galaxies. The spectrum and polarization of radio emission is an important diagnostic of the interaction informing us about the turbulence and density of the interaction region and the role of magnetic fields in both dynamics and emission. In this project the student will use magnetohydrodynamic simulations incorporating the evolution of the relativistic electron distribution to produce synthetic images of total intensity, polarization and rotation measure relating to jet-ISM interactions at high redshifts.

**More information on Canberra:**

[www.anu.edu.au](http://www.anu.edu.au) (Australian National University)

<http://visitcanberra.com.au>

[www.canberratourism.com.au](http://www.canberratourism.com.au)

# University of Western Australia

**Primary contact:** Lister Staveley-Smith (lister.staveley-smith@uwa.edu.au)

**Supervisor:** Richard Dodson

**Project title:** Delivering the goods - Data-intensive SKA-scale astronomy

**Project abstract:** Science is becoming increasingly data-intensive and this requires a new data focused approach. The prime example is the Square Kilometre Array (SKA) project, one of the world's latest large- scale global scientific endeavours, which will be co-hosted in Australia and is set to produce orders of magnitude more data than all of mankind's past accomplishments. Just one of the SKA phase-1 science projects (e.g. the HI survey) will produce derived data in the order of several terabytes per second, and the second phase of the SKA project will be at least an order of magnitude greater. This project will work on some of the most extreme datasets observed in Radio Astronomy to date, and provide a perfect test bed for the data-driven paradigm. The data will come from the Australian SKA Pathfinder, and from a Deep HI pathfinder project called CHILES. The student will investigate the ideas and methods, demonstrating new approaches on frontier data products. We are interested to hear from potential candidates from any STEM background, as the range of skill sets required (and to be developed) can not be limited to one traditional field of study. The candidate would join an active multi-disciplinary group with many scientific and commercial cross fertilisation possibilities. Similar PhD projects in this field and related science can be found at <http://www.icrar.org/study-with-icrar/postgraduate-opportunities/postgraduate-research-projects/>.

**Supervisor:** Barbara Catinella

**Project title:** Exploiting the next-generation radio surveys with spectral stacking

**Project abstract:** Atomic hydrogen gas is the raw material out of which stars are formed, and thus it is clearly of key importance for galaxy formation and evolution. Due to limitations of existing radio telescopes, our current knowledge of this crucial galaxy component is still limited to the local Universe, but this is about to change. The next-generation radio surveys planned for the Square Kilometre Array and its precursor facilities, such as the Australian Square Kilometre Array Pathfinder (ASKAP) in Western Australia, will usher in a new era for extragalactic studies, allowing us to measure the gas content of galaxies at cosmological distances. Although a large number of galaxies will be individually detected, the most stringent constraints on gas content of galaxies across cosmic time will come from spectral stacking of undetected sources. Briefly, this technique requires to co-add (i.e. "stack") the radio spectra of faint, undetected sources, for which accurate positions and redshifts are known from optical surveys, and yields an estimate of the average gas content of the ensemble. The student will build a flexible, modular, user-friendly software package to be used by the next-generation extragalactic radio surveys. The software will be tested on both available and upcoming data sets, as well as on mock catalogs generated by numerical simulations of galaxy formation and evolution. The emphasis of the first part of this project is on the computational aspect; hence a strong background in programming (especially parallel computing) is required. The second part will focus on the scientific applications, such as the determination of gas scaling relations as a function of redshift. Similar PhD projects in this field and related science can be found at <http://www.icrar.org/study-with-icrar/postgraduate-opportunities/postgraduate-research-projects/>.

**Supervisor:** Lister Staveley-Smith

**Project title:** Galaxy formation and evolution

**Project abstract:** The new Australian Square Kilometre Array Pathfinder (ASKAP) in Western Australia will be the most powerful survey instrument in the world for the study of the gaseous properties of galaxies at moderate angular resolution. It will transform our understanding of the relationship of the cool gas in galaxies with other components such as stars, ionised gas and molecular gas. It will also explore the distribution of dark matter in galaxies and in the nearby Universe. This project will use the early science phase of ASKAP (ASKAP-12) to undertake a study of the environmental properties of galaxies. In particular, we know that there are gravitational and hydrodynamic forces that will remove gas from galaxies located in massive galaxy clusters. But these forces also seem to operate in an efficient manner in smaller groups of galaxies, giving rise to a strong density dependence in the gaseous properties of galaxies that is not understood. Part of the

problem is the lack of understanding of the location of the diffuse ionised 'cosmic web' where about 50% of the normal 'baryonic' material in the Universe is supposed to reside. Part is due to lack of understanding of the early radiation conditions in dense environments. Observations with ASKAP-12 will help answer these problems by detecting and measuring the detailed properties of thousands of galaxies in a range of environments, thereby gathering sufficient information and statistical accuracy to unequivocally separate out the various physical processes and work, and helping build a fuller picture of galaxy formation and evolution. The project involves gathering 21cm ASKAP data in several early science fields, reducing and analysing the data, extracting kinematic information from the data cubes and examining systematic trends of the data with overall galaxy density as determined from optical red- shift surveys. Similar PhD projects in this field and related science can be found at <http://www.icrar.org/study-with-icrar/postgraduate-opportunities/postgraduate-research-projects/> .

**More information on Perth:**

[www.uwa.edu.au](http://www.uwa.edu.au) (University of Western Australia)

<http://www.experienceperth.com>

# University of Melbourne

**Primary contact:** Rachel Webster (r.webster@unimelb.edu.au)

**Supervisor:** Rachel Webster

**Project title:** Epoch of Re-ionisation: Foreground removal

**Project abstract:** The signal from the first stars responsible for the Epoch of Re-ionisation (EoR) in the early universe is dwarfed by radio emission from our galaxy and other radio sources along the line-of-sight. This project will develop techniques to improve the removal of foreground signals to reveal the underlying signal from the EoR. The PhD student will use the massive EoR datasets obtained from the upgraded Murchison Widefield Array, which is located on the site in Western Australia that will house the new SKA-low telescope. PhD students working on this project will be members of the MWA EoR Collaboration and the Astro-3D Centre of Excellence, working with international collaborators in the USA, Japan and China as well as the Australian EoR group. PhD students working in this area develop strong computational skills as well as deep experience in handling massive datasets. In addition, they develop a deep understanding of radio astronomy signals and signal path through a radio telescope. Opportunities will also be available to undertake theoretical subprojects related to EoR science.

**More information on Melbourne:**

[www.unimelb.edu.au](http://www.unimelb.edu.au) (University of Melbourne)

[www.visitmelbourne.com](http://www.visitmelbourne.com)

# Swinburne University of Technology

Primary contact: Edward Taylor ([entaylor@swin.edu.au](mailto:entaylor@swin.edu.au))

**Supervisor: Christopher Fluke**

**Project title:** Astronomical knowledge discovery beyond the petascale

**Project abstract:** As astronomy moves ever closer to the Square Kilometre Array's exascale data era, an increasing number of existing desktop-based workflows will fail. Instead, astronomers will turn to automated processing using dedicated high-performance computing resources coupled with advanced data archives. Yet the ability to look at the most important data is crucial. In this project, you will research, design, implement and evaluate new visualisation-based knowledge discovery approaches. The goal is to support interactive, multi-dimensional analysis of data from observations, simulations, model fits and empirical relationships. The research will require an investigation into methods for combining visualisation-directed model-fitting with emerging machine learning techniques - such as Deep Learning - to enhance and accelerate the path to discovery. A key focus will be the WALLABY survey of extragalactic neutral hydrogen with the Australian Square Kilometre Array Pathfinder (ASKAP), however, the techniques developed will be suitable for a range of current and future data intensive programs - within and beyond astronomy. All stages of the project will utilise Graphics Processing Units (GPUs) as computational accelerators. The student will also have access to Swinburne University's Advanced Visualisation facilities: the Enhanced Virtual Reality Theatre and the Swinburne Discovery Wall. This project will suit a student with existing strong programming skills, and interests in GPU-computing and/or data-intensive discovery.

**Supervisor: Deanne Fisher**

**Project Title:** An up-close view of extremely gas rich, turbulent disk galaxies

**Project abstract:** Over 80% of stars in the Universe were formed in galaxies 10 billion years ago. These galaxies were marked by drastically high densities of star formation, were super rich in gas, and show evidence of widespread turbulence. Because these galaxies are so different from those galaxies in the local Universe, we cannot assume that local theories of star formation robustly explain such extreme environments. However, these galaxies are also very distant from us. We therefore cannot resolve the star forming regions. This situation has created a very large problem for galaxy evolution: We do not currently understand star formation processes in the most important epoch of galaxy evolution in the history of the Universe. Our group has mined datasets of hundreds of thousands of galaxies to find a set of rare galaxies in the local Universe which are very closely matched to conditions in galaxies 10 billion years ago. This PhD project will study the properties of these galaxies to determine the stellar mass, stellar populations, star formation rates and gas masses of these massive complexes of star formation found inside nearby turbulent, gas rich galaxies (called the DYNAMO sample). This project has recently been awarded time on Hubble Space Telescope, the Atacama Large Millimeter Array (ALMA), as well as having data from programs with Hubble, NOEMA and Keck. In the future we will use SKA data to determine the amount of HI gas in these interesting galaxies (through the atomic hydrogen 21 cm line), as well as probe embedded star formation using radio continuum.

**Supervisor: Adam Deller**

**Project Title:** General-purpose GPU-based radio interferometry instrumentation for high time resolution studies of pulsars and Fast Radio Bursts

**Project abstract:** General purpose "software"-based backends for radio interferometers such as the Distributed FX (DiFX) software correlator have proven remarkably successful in providing flexible signal processing solutions that can be quickly and cheaply adapted to multiple use cases. At the same time, highly tuned signal processing implementations on Graphics Processing Units (GPUs) have become widely used for systems with more demanding computational requirements. However, to date, the two concepts have not yet been married into a highly performant yet still flexible and general purpose implementation of correlation and beamforming on GPUs. Such a system would find a wide range of applications, from wide-band Very Long Baseline Interferometry to high time resolution studies of Fast Radio Bursts with the Australian SKA Pathfinder (ASKAP). This project will focus on developing

a highly performant GPU-based correlator/beamformer, which can be flexibly configured along the lines of the DiFX software correlator yet process a comparable computational load at much reduced cost (or with much reduced latency). The completed system will be initially applied to low-latency, high-time resolution studies of ASKAP Fast Radio Bursts and ultimately to other applications as desired by the successful candidate.

**Supervisor: Glenn Kacprzak**

**Project Title:** How do galaxies continue to form stars?

**Project abstract:** The circumgalactic medium represents a massive reservoir of gas around galaxies and provides a possible fuel source for future star formation. It remains unclear how the circumgalactic medium feeds galaxies in order for them to continue to grow. Here we will address this question by measuring the star-formation rates of low redshift galaxies that have associated HI and metal-line absorption detected within their halos using nearby bright background quasars. We aim to establish whether there is a causal connection between the rate at which galaxies form stars and their gas reservoirs. We will further investigate how the circumgalactic gas moves towards galaxies and determine how this gas makes its way onto the HI galaxy disk typically seen in emission.

**Supervisor: Karl Glazebrook and Adam Deller**

**Project Title:** Finding Strong Gravitational Lenses in the High-Resolution imaging era

**Project abstract:** Strong gravitational lens systems are a corner piece for the study of cosmology, dark matter and galaxy evolution. It has now been established that they can be found very efficiently using convolutional neural networks (a.k.a. 'deep learning') in ground based surveys, searching millions of sources to find hundreds of lenses. In this PhD project we will develop the next generation of machine learning techniques that will be able to detect strong lenses in future high-spatial resolution large imaging surveys. These include orbiting observatories such as Euclid and the Chinese Space Telescope which will survey thousands of square degrees in the optical at resolution similar to the Hubble Space Telescope, and forthcoming SKA and VLBI radio surveys which can deliver resolutions down to milliarcseconds for millions of sources. Key research problems to be addressed are: (i) simulate lensed galaxies at much higher spatial resolution in order to provide realistic training samples, (ii) simulate instrumental effects in the radio domain and (iii) will explore new techniques such as transfer learning and generative adversarial networks to build more adaptable systems.

**Supervisor: Fan Liu and Michael Murphy**

**Project Title:** Open clusters: a key for Galactic Archeology

**Project abstract:** Open clusters are fundamental stellar building blocks of the Milky Way and, presumably, all galaxies. Stars in an open cluster are assumed to have formed together and should have the same chemical composition. However, this key assumption began to be challenged by recent spectroscopic studies, where extremely high precision in elemental abundances (5%, 0.02 dex) was achieved. These studies revealed subtle differences in elemental abundances in a few open clusters, which could be due to, e.g., stellar evolution and diffusion, environmental pollution, and planet formation. In this project we will explore two fundamental questions: (1) Are open clusters chemically homogeneous?; and (2) Is each open cluster unique? The results we obtain will have significant implications for Galactic Archeology – the history and process of building our own Milky Way Galaxy. The student will conduct a systematic study of the detailed chemical abundances of stars belonging to a number of benchmark open clusters with different ages and chemical compositions. We aim to investigate and quantify the level of (in)homogeneity in the open clusters (i.e. star-to-star abundance variations and intrinsic abundance scatters) for different elements. We will also study the cluster-to-cluster abundance differences, in order to discover their unique abundance pattern.

**More information on Melbourne:**

[www.swinburne.edu.au](http://www.swinburne.edu.au) (Swinburne University of Technology)

[www.visitmelbourne.com](http://www.visitmelbourne.com)

# Curtin University

**Primary contact:** James Miller-Jones (james.miller-jones@curtin.edu.au)

**Supervisor:** Ben McKinley (ben.mckinley@curtin.edu.au)

**Co-supervisor:** Adrian Sutinjo

**Project Title:** Imaging with an array of omnidirectional dipoles

**Project Abstract:** One of the main science goals of the Square Kilometre Array - Low is to measure the redshifted 21-cm signal from the early Universe using power spectra and direct imaging. Experiments aiming to detect the all-sky or 'global' signal from hydrogen will provide a crucial consistency check for any SKA detection. Bowman et al. (2018) claim to have detected the much sought-after absorption trough in the global, redshifted 21-cm signal from the Cosmic Dawn with the Experiment to Detect the Global EoR Signature (EDGES). The centre frequency and shape of this signal, which contains information on the first stars and galaxies that heated the early Universe, was unexpected and requires new physics to explain. There is therefore great interest in obtaining an independent verification of the detection. A Chinese-led mission currently in the approval stage, is aiming to do this by placing an array of low-frequency antennas in orbit around the Moon, using it as a shield from Earth-bound interference. The mission concept and additional science objectives are similar to a previously proposed mission; 'Discovering the sky at the Longest Wavelengths' (DSL; Boonstra et al. 2016).

This ambitious space mission will require innovative new calibration and imaging techniques as it uses omnidirectional antennas in a three-dimensional distribution. Such a low-frequency interferometer has never been built and tested, hence the aim of this PhD project. The PhD student will work as part of a team to design, build and test a ground-based prototype of a three-dimensional array of omnidirectional antennas. Depending on the student's skills and interest they may be involved in design simulations, development of calibration and imaging strategies and algorithms, hardware prototyping and instrument testing. As well as developing and testing imaging algorithms for the space mission, the project will itself produce all-sky maps of the sky at low frequencies, which may be used for calibration of ground-based experiments such as the SKA-Low and space-based experiments. Imaging techniques developed and tested will also be useful to other radio arrays that see almost the full sky, such as the SKA-Low verification arrays currently under development.

**Supervisor:** Ramesh Bhat (Ramesh.Bhat@curtin.edu.au)

**Co-supervisor:** Jean-Pierre Macquart

**Project Title:** Finding exotic pulsars using the FAST and the First SKA-Low Precursor Telescope

**Project Abstract:** Pulsars are proven laboratories of nature for advancing fundamental physics; those with spin periods of the order of a few milliseconds, or in short binary orbits with another star, are particularly promising for a wide variety of science. Specifically, the clock-like stability of their pulse arrival times can be exploited for applications ranging from searching for ultra-low frequency gravitational waves to probing the state of ultra-dense matter. This array of exciting science is enabled by discoveries of exotic pulsars that allow us to probe new physics, in particular physics under extreme conditions, such as strong-field gravity or matter at nuclear densities. Indeed doing *fundamental physics* with pulsars is a recognised headline science theme for the upcoming Square Kilometre Array (SKA) telescope.

The unprecedented collecting area of FAST makes it the most sensitive instrument to search for pulsars, as vividly demonstrated by new pulsar discoveries and candidates that are emerging from ongoing early science projects with FAST. On the other hand, the massively large field of view of the Murchison Widefield Array (MWA) makes it an excellent survey instrument at low frequencies. Efforts are underway to build a high time resolution digital archive of the entire southern sky with the upgraded MWA (Phase 2), the data from which can be readily mined for important confirmation and/or follow-up observations of new pulsar discoveries/candidates that are emerging from the FAST. Similarly, the ongoing high-time resolution and imaging studies using the MWA are beginning to

uncover potential pulsar candidates through the techniques of interplanetary scintillation (IPS) and difference imaging, which can be efficiently followed up using the high-frequency capabilities of FAST. This project will facilitate the combined use of two major radio facilities, the FAST and the MWA, to undertake rapid follow-up and confirmation of promising pulsar candidates. Besides the prospects of discovering exotic pulsars in the large common skies of the two facilities, this will also constrain the spectral, scattering and emission of properties of a substantial pulsar population, which is valuable to predict pulsar survey yields expected with SKA1-Mid and SKA1-Low.

**Supervisor:** Nick Seymour ([nick.seymour@curtin.edu.au](mailto:nick.seymour@curtin.edu.au))

**Project Title:** Understanding the Radio Emission from Star Forming Galaxies in the SKA Era

**Project Abstract:** Deep radio surveys are a superb tracers of star formation across cosmic time. Surveys with the Square Kilometre Array (SKA) will be dominated by star forming galaxies, and determining the star formation history of the Universe is a Key Science goal of the SKA. This forecast motivates us to better understand the astrophysical origin of radio emission from star forming galaxies. Preliminary work ([Galvin et al. 2018](#)) has shown that the broad-band radio emission (from 0.1-10 GHz) is far more complex than previously expected and reveals insights into origin of radio emission.

This project will extend the broad-band radio analysis to star forming galaxies in the GAMA23 survey field allowing us to probe more distant and less luminous galaxies. It will use data from the Murchison Widefield Array (MWA: 70-300 MHz), uGMRT (~400 MHz), Australian SKA Pathfinder (ASKAP 0.7-1.8 GHz) and the Australia Telescope Compact Array (ATCA: 5-9 GHz). This project will involve: learning to observe with the ATCA, learning to reduce MWA data, determining the radio flux densities across 0.07-9 GHz for star forming galaxies in the GAMA23 field (leveraging the wealth of multi-wavelength data in this field). This data set will be used to develop models of the radio emission from star forming galaxies providing a local benchmark with which to interpret future deep SKA surveys. This project will also look for trends with star formation rate, environment and stellar mass, amongst other trends.

**More information on Perth:**

[www.curtin.edu.au](http://www.curtin.edu.au) (Curtin University)

<http://www.experienceperth.com>

# University of Tasmania

**Primary contact:** John Dickey (john.dickey@utas.edu.au)

**Supervisor:** Stas Shabala

**Project title:** An environmental census of black hole activity and star formation

**Project abstract:** Many galaxy properties, including mass, star formation history and morphology, are correlated with their environments. The properties of Active Galactic Nuclei (AGN) hosted by these galaxies are similarly sensitive to where the galaxy finds itself. For example, powerful radio AGN, produced by relativistic jet launching by a combination of spin and accretion onto a supermassive black hole, are found overwhelmingly in galaxy groups and clusters. Interpreting the observable properties of radio AGN is important for quantifying the amount of feedback these objects do on their host galaxies and beyond, yet this too depends on knowledge of the environment into which the jets are propagating.

GAMA Legacy ATCA Southern Survey (GLASS) is a 3000-hour Legacy survey on the Australia Telescope Compact Array (ATCA), Australia's premier radio astronomy instrument. GLASS conducts sensitive observations of 50 square degrees of the sky at 5.5 and 9.5 GHz. A key feature of GLASS is availability of environment measures through deep optical group catalogues covering the survey field. The two main science goals are to measure the demographics of Active Galactic Nuclei and star forming galaxies in both the nearby and high-redshift Universe, as a function of environment.

This PhD project will focus on studied of GLASS radio sources and their host galaxies across a wide range of radio, optical and infra-red wavelengths, for a complete census of AGN, star forming galaxies, and their environments. For an interested student, an AGN modeling component using the UTAS-developed RAISE dynamical model and numerical jet simulations is also a possibility.

**Supervisor:** John Dickey

**Project title:** The HII Region Population in the Milky Way

**Project abstract:** The Southern HII Region Discovery Survey (SHRDS) is a radio frequency survey of the Milky Way Galactic plane, using the Australia Telescope Compact Array telescope. Coupled with a similar survey in the Northern Hemisphere, the SHRDS has detected radio recombination line emission from some 200 new HII regions in the inner Galaxy. The challenge now is to determine the distances, chemical compositions, masses and temperatures of these regions. Using the existing data, plus new observations from telescopes at UTAS and CSIRO, the Ph.D. student will map the structure and motions of our Galaxy. In particular, HII regions trace spiral arms, and the SHRDS will allow a more complete picture of the spiral structure of the Milky Way to be drawn. The project combines technical expertise working with telescopes and radio astronomy data calibration, with numerical modelling and radiative transfer astrophysics to interpret the data in the context of the interstellar medium.

**Supervisor:** Simon Ellingsen

**Project title:** Dense Gas across the Milky Way

**Project abstract:** Understanding our own Galaxy is of the utmost importance to many branches of astronomy and astrophysics. To quote an important recent review of Galactic astrophysics "Our Galaxy, the Milky Way, is a benchmark for understanding disk galaxies...Galactic studies will continue to play a fundamental role far into the future because there are measurements that can only be made in the near field and much of contemporary astrophysics depends on such observations" (Bland-Hawthorn et al. 2016). Crucially, in order to understand galaxies we must solve one of the most fundamental mysteries of our Universe - one of the six 'big questions' posed in the 2016 Decadal Plan for Australian Astronomy: How do stars and planetary systems form? This PhD project will directly address this fundamental question.

The University of Tasmania is collaborating in a "Legacy" science project being undertaken with the Australia Telescope Compact Array (ATCA) that is building on Australia's rich tradition of spectral line legacy surveys to deliver a 7-mm dense gas survey of the Fourth Quadrant Galactic Plane in multiple molecular spectral lines and continuum emission. This will address a wide range of astrophysical

challenges, including directly testing competing theories of massive star formation and mapping the dense gas structure of the Milky Way through to the far side of the Disk. By locking in key measurements in our "astronomical backyard", the project will provide a crucial astrophysical template that will allow us to interpret future sensitive, high-resolution surveys of external galaxies with ALMA and the SKA.

This project will involve utilising the Australia Telescope Compact Array to make sensitive, high-resolution observations of the dense-gas molecular tracer CS, along with methanol masers and range of other molecular tracers. These data will be used to obtain a census of high-mass star forming regions (through CS, SiO, methanol masers and radio continuum observations) and directly test theoretical predictions of high-mass star formation and their precursors, feeding directly into future work on high-mass star formation.

**More information on Hobart:**

[www.utas.edu.au](http://www.utas.edu.au) (University of Tasmania)

[www.discovertasmania.com.au](http://www.discovertasmania.com.au)