CAS HONOURS PROJECT LIST 2022

Dark Matter and Massive Galaxies

Supervisor: Dr Tania Barone
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Project description: What is dark matter and how much of it can be found in galaxies are two open questions that are still puzzling astronomers. We can study dark matter by comparing the total mass of a galaxy with how much mass we can actually see (in stars and gas). But how do we measure what we can't see? For some galaxies, a rare chance alignment with another background galaxy gives us a unique opportunity to measure its gravitational influence, and therefore its total mass. When a massive foreground galaxy happens to perfectly align in front of another background source, the foreground target gravitationally lenses the light from the background galaxy. From this gravitational lensing effect, we can precisely measure its total mass: dark matter and all. We have a growing sample of these rare massive lensing galaxies as part of the ASTRO 3D Galaxy Evolution with Lenses (AGEL) survey. The project will involve comparing the measurements of the stellar mass and the total mass of our lensing galaxies to uncover the dark matter hiding within. We'll predominantly be using Python to study the data. Prior Python experience would be useful but definitely not a requirement, as you'll learn along the way. As part of this project you'll get to be part of a diverse and friendly research team that spans multiple universities and continents!

Detecting gravitational waves from core-collapse supernovae

Supervisor: Dr Jade Powell
Contact: jpowell@swin.edu.au

Project description: The first detections of gravitational waves were made during the last few years. The sources of those gravitational waves were binary neutron stars and black holes. Gravitational wave detectors are currently offline to improve their sensitivity for their next observing run. As the detectors become more sensitive, they may begin to detect gravitational waves from other sources. One of those potential sources is a nearby core-collapse supernova. Supernovae are a perfect multi-messenger source as they can be detected electromagnetically and in gravitational waves and neutrinos. A gravitational wave detection may tell us about the mechanism driving the explosion. In this project, you will develop data analysis techniques for the detection and parameter estimation of core-collapse supernovae in data from the LIGO and Virgo gravitational wave detectors.

Exploring the Dynamic Radio Sky

Supervisor: Dr Dougal Dobie
Contact: ddobie@swin.edu.au

Project description: The Australia Square Kilometre Array Pathfinder is a next-generation radio telescope in Western Australia. As part of the Variables And Slow Transients (VAST) survey, we have carried out an initial pilot survey comprising of regular observations of over 10% of the entire sky over the past year. Phase 2 of the pilot is currently underway, while the full survey is expected to begin in mid-2022. There are a number of possible projects available, including (but not limited to) searching for the radio afterglows of transient events (e.g. supernovae, tidal disruption events and gamma-ray bursts), studying known variable sources (e.g. x-ray binaries, pulsars) and developing software to carry out these searches (e.g. transient detection and classification with machine learning). The overall direction of the project will be determined by the student's interests and the status of the survey at the beginning of their research period.

Further reading:

- Murphy, T., Kaplan, D.L., Stewart, A., et al. (2021), accepted PASA
- Pritchard, J., Murphy, T., Zic, A., et al. (2021), MNRAS, 502, 4
- Leung, J., Murphy, T., Ghirlanda, G., et al. (2021), MNRAS, 503, 2

Exploring the evolution of massive binary stars with gravitational waves

Supervisor: Dr Simon Stevenson
Contact: spstevenson@swin.edu.au

Project description: Gravitational waves have now been observed from several different types of merging binaries, including various combinations of neutron stars and black holes. These binaries may be the end result of the evolution of pairs of massive stars evolving in isolation in galactic fields through mass transfer, common envelope episodes and supernovae. Modelling these processes is difficult, and in population synthesis codes like COMPAS they are parametrised to describe our ignorance. Population synthesis studies typically explore the impact of these uncertainties by varying one parameter at a time, and quantifying the outcome on a quantity of interest, such as the merger rate of compact object binaries. In this project you will begin to explore ways we can go beyond these simple parameter variations to help us understand the *correlated* impact of uncertainties in binary evolution. You will begin by familiarising yourself with the topics of binary evolution, population synthesis and gravitational waves. The bulk of the project will involve exploring, understanding and quantifying the correlated impact of uncertainties in massive binary evolution on the production of compact object binaries. If time permits, we will compare these results to the most up-to-date catalogues of gravitational-wave and/or radio observations of compact object binaries.

Further reading:

- Stevenson et al. 2017 (https://arxiv.org/abs/1704.01352)

De-blending of strong lensing images using neural networks

Supervisor: Dr Colin Jacobs
Contact: colinjacobs@swin.edu.au

Project description: Strong Gravitational Lensing is a rare and beautiful phenomenon that can teach us much about gravity, matter and cosmology. Lensing occurs when a massive body such as a galaxy or cluster of galaxies bends the light of more distant objects, resulting in distinctive magnified arcs, rings and multiple images from our viewpoint here on Earth. Studying strong lensing has many scientific applications, including understanding the distribution of dark matter, constraining cosmological parameters, and observing distant galaxies that would otherwise be too faint to study. Exploiting the scientific potential of strong lenses requires building a model of lens system. This requires an understanding of the light profiles of both the lensing galaxy, and the distant source; which parts of the image, and how much light, is coming from each. Various techniques have been used to do this "deblending". Here we experiment with using artificial neural networks to perform this task. Although robust methods exist to find galaxy light profiles, lenses are complicated by the presence of a distorted background source. Student will use simulated lenses with known light profiles and train a machine learning model to recover those profiles, and see how the accuracy of the network changes as a function of the quality of the image. If time permits, the use of neural networks for image segmentation - highlighting the pixels in the image that are dominated by the light of the lens, or the lensed source. Simulations will be provided, however some previous exposure to machine learning and python programming is desirable. The student will utilise and expand skills in python programming, machine learning, Linux and high-performance computing.

Further reading:

- A brief history of gravitational lensing https://www.einstein-online.info/en/spotlight/grav_lensing_history/
- Finding strong lenses in CFHTLS using convolutional neural networks https://ui.adsabs.harvard.edu/abs/2017MNRAS.471..167J/abstract
- Fast automated analysis of strong gravitational lenses with convolutional neural networks https://www.nature.com/articles/nature23463
- Semantic Image Segmentation using Fully Convolutional Networks: https://towardsdatascience.com/semantic-image-segmentation-using-fully-convolutional-networks-bf0189fa3eb8

Local globular clusters as a ground truth for galaxy stellar population analysis methods

Supervisor: Dr Themiya Nanayakkara
Contact: wnanayakkara@swin.edu.au

Project description: Understanding the properties of the stars in the early Universe is driven by the analysis of integrated light of galaxies. Even with the best telescopes these galaxies are merely observed as small blobs in the sky. Using spectrophotometric data from these galaxies, a variety of theoretical stellar population models and bayesian inference methods are used by astronomers to make crucial assumptions about the properties of the stars and gas from *cosmic dawn* to *cosmic noon*. The accuracy of such fitting routines to reproduce the observables and thus the conditions of the galaxies are generally quantified via mock observables. Application to real observed data where these properties are independently measured is often overlooked. In this project, you will address this issue by looking into local globular clusters as a benchmark for stellar population properties of galaxies. You will use a sample of globular clusters, whose properties are well constrained through colour-magnitude diagram analysis and through spectroscopy of individual stars, to create observables as inputs for a variety spectral energy distribution fitting softwares. Previous experience in programming (e.g. python) and some knowledge in statistics would be beneficial for this project.

Further reading:

- Spectroscopic ages and metallicities of stellar populations: validation of full spectrum fitting, Koleva et al. 2008, MNRAS https://ui.adsabs.harvard.edu/abs/2008MNRAS.385.1998K

(more projects follow…)

Predicting the future of the Universe!

Supervisor: Prof Chris Blake
Contact: cblake@swin.edu.au

Project description: Astronomers have found strong evidence that the Universe is entering a phase of domination by dark energy, which is speeding up the cosmic expansion. However, the properties of dark energy, and hence its evolution into the future, remain uncertain. In this project we will forecast different cosmological futures, using calculations in cosmology and General Relativity to determine the future impact of dark energy on the Universe, our Galaxy and solar system. What effect do dark matter and dark energy have on planetary orbits, and what does it take to rip them apart? In this Project you will develop your coding and research skills to answer this question!

Further reading:

- https://arxiv.org/pdf/astro-ph/0302506.pdf

Space system real-time data fusion, integration and cognition

Supervisor: Prof Chris Fluke
Contact: cfluke@swin.edu.au

Project description: The *volume* of data collected from satellites has already exceeded the capacity of the user community to undertake exhaustive visual inspection and analysis. As the *velocity* of data collection grows, appropriate support for real-time data-driven discovery and decision-making becomes crucial. By bringing together (i.e., fusing) a *variety* of data sources, the potential for new insight and knowledge grows, but this brings further challenges for real-time processing and quality control of the integrated data products. Honours Projects are available in the following four theme areas:

- *Cyber-human teaming*, where human performance at cognition and visualisation is enhanced when working in partnership with intelligent agents, with primary applications in high-risk, time-dependent contexts include defence, space operations, and space domain awareness.
- *Visual analytics*, with primary application in the utilisation of Earth Observation data, based on the development of new approaches to data fusion and integration that utilise high-performance and accelerated computing architectures to work at scale.
- *Extend Reality (XR) Visualisation and Discovery*, leveraging the continued emergence of virtual reality and augmented reality head-mounted displays to enhance insight and understanding from Earth Observation data in all its forms by supporting novel data discovery and decision-making methods.
- *In-space computing*, where data fusion and analysis processes occur on-board satellites, taking advantage of improved processing and storage capability, and addressing the limitations of the "I/O bottleneck" imposed by downlink rates and bandwidth.

End-user applications will be explored from fields including: agriculture, mining and natural resources, public health, disaster resilience, defence, space domain awareness, and space operations.

Location, location, location: Small Haloes, Big Potential (Wells)

Supervisor: A/Prof Michelle Cluver and Prof Darren Croton
Contact: mcluver@swin.edu.au and dcroton@swin.edu.au

Project description: The smallest (lowest halo mass) groupings in the universe are the pairs and triples; these nascent groups are expected to be gas-rich systems, particular susceptible to the impact of merging and stripping. In addition, there are indications that their gas content is anti-correlated to large scale structure density. In this project, we will make use of a unique data set, constructed by our team, that contains mid-infrared estimates of stellar mass and star formation rates for ~24 000 z<0.1 galaxies across ~385 square degrees. By investigating the properties of pairs and triples with respect to the large scale structure, we can examine the possible implications of location and density in the evolution of the most numerous groups in the local universe.

Further reading:

- Eckert, K. et al. 2016, The Halo Mass-dependent Shape of Galaxy Stellar and Baryonic Mass Functions, The Astrophysical Journal 824. doi:10.3847/0004-637X/824/2/124
- Stark, D.V. et al. 2016., The RESOLVE Survey Atomic Gas Census and Environmental Influences on Galaxy Gas Reservoirs, The Astrophysical Journal 832. doi:10.3847/0004-637X/832/2/126
- Cluver, M.E. et al. 2020, Galaxy and Mass Assembly (GAMA): Demonstrating the Power of WISE in the Study of Galaxy Groups to z < 0.1, The Astrophysical Journal 898. doi:10.3847/1538-4357/ab9cb8

The Search for Pristine Gas Clouds in Starbursting Galaxies

Supervisor: A/Prof Deanne Fisher
Contact: dfisher@swin.edu.au

Project description: In this project, the student will work with data from the new, cutting-edge instruments on both the Keck telescope and VLT to study the accretion and star formation feedback in extreme star forming galaxies. Our team is studying stellar feedback through direct measurement of the gas and detailed study of the extreme populations of stars that drive this feedback. This project focuses on what drives these extreme star formation rates by searching for the signatures of freshly accreted gas in galaxies. In 2019 and 2020 we were awarded several nights of Keck time for a survey called DUVET using the cutting edge KCWI spectrograph. We additionally include several targets with VLT/MUSE data. This project will focus on identifying regions within these galaxies of metal-poor gas. High star formation rates are likely to result from accretion of gas from the Universe around it. Gas from outside the galaxy can be found by searching for regions in the galaxy that have lower metal content. The student will learn the physics of the interstellar medium gas, they will learn the practical skills of using python code, processing IFU (integral field unit) spectroscopic data, and for astronomy purposes learn how to continuum subtract spectra of star forming galaxies. All needed data is taken, we only need you to work on this exciting data set. This project is key program in the Australia-wide Astro3D collaboration, which will give the student access to national networking activities. The student will join monthly Australia wide Astro3D galaxy evolution meetings, and will be encouraged to present their results to the team. The student will join a team at Swinburne that includes multiple professors and postdoc and three graduate students. If successful there is scope to continue working in our team with later projects towards a PhD.

Further reading:

- Putnam et al. 2017 https://arxiv.org/pdf/1612.00461.pdf

The Search for Gas In Between Galaxies

Supervisor: A/Prof Deanne Fisher
Contact: dfisher@swin.edu.au

Project description: In this project the student will work with data from the MAGPI survey using MUSE on the VLT. Galaxies in the Universe cycle gas into galaxies through accretion and out of galaxies through violent outflows driven by supernova and AGNS. This process is known as the baryon cycle. The baryon cycle is critically important for maintaining the star formation rates of galaxies and growing their mass. Recent advancements allow us to observe gas at extremely faint surface brightness with very long exposures using instruments like MUSE. We can now, for the first time directly observe the gas that is outside the galaxy, and thus learn details of the state of gas as it is in the phase of the baryon cycle that is outside of galaxies. The MAGPI survey is a 400 hour program with VLT of very long exposures of galaxies at z=0.3. It is the first large program lead by Australians on the VLT, one of the most cutting edge telescopes on the planet. The survey team is spread across a number of universities in Australia and Europe. Studying gas in between galaxies is a new, and exciting area of science, and if successful the results could both lead to a publication and provide scope for a longer term PhD project in the future. The student will work with this exciting data set. They will learn practical skills such as using python code, working with integral field data sets, and identifying and measuring emission lines. Locally the student will be a member of a team at Swinburne that includes multiple professors, a postdoc and 3 graduate students. The student will take part in MAGPI team meetings, and at present the results of their project to the MAGPI team.

Further reading:

- Chen et al. 2019 https://arxiv.org/pdf/1906.00005.pdf
- Foster et al 2021 https://arxiv.org/pdf/2011.13567.pdf

The Final Frontier

Supervisor: Prof Duncan Forbes
Contact: dforbes@swin.edu.au

Project Description: The Hubble Space Telescope obtained spectacular deep images of several galaxy clusters in a program called the Frontier Fields (https://frontierfields.org). An analysis of the images revealed that the clusters contained an abundance of so-called Ultra Diffuse Galaxies (UDGs). These are very low surface brightness galaxies that contain huge amounts of dark matter and challenge our theories of galaxy formation. The project involves matching up our catalogue of UDGs in the Frontier Fields to recent spectral data from the Very Large Telescope in Chile. Once matched, spectra can be extracted and the redshift of each UDG determined. This allows us to confirm cluster membership of the UDG and to create a diagnostic diagram of when they fell into the cluster. This infall diagnostic is a key test of UDG formation theories. Thus the project combines cutting-edge imaging from Hubble with recent spectral data. The successful candidate should be able to attend a Keck observing run from our remote ops room. The project offers avenues for expansion and possible publication in a refereed journal.

Further reading:
- https://arxiv.org/pdf/1911.00011.pdf
- https://arxiv.org/pdf/1701.00011.pdf

Discovery of new star clusters around dwarf galaxies

Supervisor: Prof Duncan Forbes
Contact: dforbes@swin.edu.au

Project description: Our Milky Way galaxy contains around 200 globular (star) clusters. However low mass galaxies are less well-studied and contain fewer GCs – sometimes only a single GC or even none at all. This project will utilise some existing Keck telescope spectra to confirm the association of some GC candidates around several nearby dwarf galaxies (eg DDO190, F8D1 and IKN). Once radial velocities (redshifts) are measured and association confirmed, the next step is to measure structural and photometric properties of the GCs from archive imaging. A second option in this project is to use survey data from the SPLUS and JPLUS surveys to identify GCs in nearby dwarf galaxies. These surveys provide 12 photometric bands and hence brightness measures at 12 different wavelengths. Fitting these data can not only identify new GCs but also estimate their mass, age and chemical composition. The successful candidate should be able to attend a Keck observing run from our remote ops room. The project offers avenues for expansion and possible publication in a refereed journal.

Further reading:
- https://arxiv.org/pdf/astro-ph/0505624.pdf
- https://arxiv.org/pdf/1907.01567.pdf

Stellar bars: (peanut shell)-shaped structures in face-on disk galaxies

Supervisor: Prof Alister Graham
Contact: agraham@swin.edu.au

Project description: A growing number of galaxies with grand stellar bars - residing within their host galaxies' flattened disk of stars - are known to additionally display a (peanut-shell)-shaped pattern. It is commonly known that these bars can wobble and buckle above and below the disk plane, forming these patterns. However, unbeknown to most astronomers and rarely observed, this bar-buckling phenomenon can also occur within the disk plane. We have recently developed a new method for quantifying these bar+peanut structures in terms of the 6th-order Fourier Harmonic deviation from purely elliptical isophotes. In 2018, we provided the first measurement of such an in-plane peanut in a galaxy whose disk is orientated face-on. We have identified ~10 more such galaxies, and wish to measure their physical structure for comparison with the peanuts which have formed out of the disk plane, yielding insight into the relative strength of the vertical (out-of-plane) and horizontal (in-plane) bar-instability. This project will provide training with telescope data, involvement with front line galaxy research, and preparation for various PhD projects involving galaxy image analysis which our team use to study the connection with a galaxy's central supermassive black hole.

Further Reading:

- https://astronomynow.com/2016/05/08/astronomers-detect-double-peanut-shell-galaxies/, https://arxiv.org/abs/1603.00019
- https://arxiv.org/abs/1712.00430, https://arxiv.org/abs/2101.04157

The missing population of intermediate mass black holes

Supervisor: Prof Alister Graham
Contact: agraham@swin.edu.au

Project description: There is a largely missing population of intermediate-mass black holes (IMBHs) with masses higher than that formed by single stars today (1.4 to ~100 solar) and less massive than the supermassive black holes (SMBHs: 10^5-10^10 solar) known to reside at the centres of giant galaxies. It has been speculated that IMBHs may be the seeds of the SMBHs. The growth of galaxies by the acquisition and merger of smaller galaxies or star clusters may bring in these seeds. We have discovered a sample of spiral galaxies with off-centre, X-ray active hotspots, signalling black holes, and maybe IMBHs. This project will search the immediate vicinity of the hotspots looking for the remains of semi-digested galaxies or star clusters that may have brought in these potential IMBHs, as seems to be the case in the galaxy NGC 4424. This project will provide training with satellite data, involvement with front line galaxy research, and preparation for various PhD projects involving galaxy image analysis.

Further reading:

- https://arxiv.org/abs/0910.1356, https://arxiv.org/abs/1507.02691
- https://arxiv.org/abs/1811.03232

Probing cosmological variability of fundamental constants with quasar spectra

Supervisor: Prof Michael Murphy
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Project description: Distant galaxies, seen in silhouette against bright, background quasars, imprint a characteristic pattern of absorption lines onto the quasar light as it travels to Earth. This pattern is determined by the fundamental constants of nature. Using spectra taken with the largest optical telescopes in the world (e.g. Keck and Subaru in Hawaii, VLT in Chile), this pattern can be compared with laboratory spectra to determine whether the fundamental constants were indeed the same in the distant, early universe as we measure them on Earth today. Several different avenues are available for exploration in this project. For example, one option is to analyse new spectra taken from the Keck and/or VLT with the aim of measuring the variability of the fine-structure constant (effectively, the strength of electromagnetism). Another option is to improve the methods used to make these exacting measurements so that we can make the best use of a new instrument being built on the VLT specifically for such work. These and other options will be discussed with the candidate.

Further reading:

- Evans T.M., Murphy M.T., Whitmore J.B. et al., 2014, Mon. Not. Roy. Astron. Soc., 445, 128
- Murphy M.T., Malec A.M., Prochaska J.X., 2016, Mon. Not. Roy. Astron. Soc., 461, 24613

Searching for rare metals in the distant universe with quasar spectra

Supervisor: Prof Michael Murphy
Contact: mmurphy@swin.edu.au

Project description: How the heavy elements originated in stars is an enduring problem in astrophysics, as is the question of how exploding stars polluted the gaseous surroundings of galaxies. This project will draw upon a large database of the highest-quality spectra of quasars in the distant universe, the lines-of-sight to which probe gas around foreground galaxies. The aim is to combine these spectra to search for absorption lines from heavy elements not previously seen outside our own galaxy. Identifying these rare metals can help diagnose the physical and nucleosynthetic origins of the absorption clouds, and may greatly improve future measurements of the fundamental constants in the distant universe.

Further reading:

- Prochaska J.X., Howk J.C., Wolfe A.M., 2003, Nature, 423, 57

Detecting double-peaked Lyman-alpha at redshift 6 with MAVIS

Supervisor: A/Prof Emma Ryan-Weber
Contact: eryanweber@swin.edu.au

Project description: Determining the amount of ionizing radiation from early galaxies is key to understanding the Epoch of Reionziation. The problem is that ionizing radiation cannot be detected directly at redshift 6. One of the most robust proxies for ionizing radiation is the peak separation of Lyman-alpha emission. To achieve such measurements a resolution of R> 5000 is ideal. Australia will co-lead a new instrument on the Very Large Telescope: MAVIS, the Multi-conjugate Adaptive optics assisted Visible Imager and Spectrograph. The aim of this project is to demonstrate that double-peaked Lyman-alpha can be detected at redshift 6 with MAVIS. The project will involve analyzing high resolution spectra from the Hubble Space Telescope of lower redshift galaxies known as 'green peas'. The spectra of the green peas will be shifted to high redshift and degraded to MAVIS resolution and sensitivity and re-analysed to assess whether the double peak can be recovered.

Further reading:

- https://www.jwst.nasa.gov/content/science/firstLight.html
- https://mavis-ao.org/mavis/
- https://ui.adsabs.harvard.edu/abs/2018MNRAS.478.4851I/abstract
- https://ui.adsabs.harvard.edu/abs/2015A%26A...578A...7V/abstract

Assessing the precision of nature's greatest clocks

Supervisor: A/Prof Ryan Shannon
Contact: rshannon@swin.edu.au

Project description: Millisecond pulsars are rapidly and stably spinning neutron stars beaming radio emission that we observe as pulses. The regularity of the pulses allows them to be used as clocks in space. Through the monitoring of pulsars for years to decades, they can be used to test General Relativity, determine the composition of nuclear matter, and search for ultra-long wavelength gravitational waves. All of this relies on the precise time tagging of the pulses, which usually assumes that all of the pulses from a given pulsar have the same shape. In this project you will test this assumption. You will first search for pulse shape variations in millisecond pulsars observed with the state-of-the-art MeerKAT telescope in South Africa as part of the MeerTime project. You will then determine whether the shape variations are intrinsic to the pulsar or caused by the interstellar medium between the pulsar and us. To conclude you will assess the impact of the shape variations on precision timing experiments, and what can be learned about pulsars and the interstellar medium from the pulse shape variations.

Further reading:

- Shannon et al. 2016. "The disturbance of a millisecond pulsar magnetosphere" https://arxiv.org/abs/1608.02163
- Bailes et al. 2020. "The MeerKAT telescope as a pulsar facility: System verification and early science results from MeerTime" https://arxiv.org/abs/2005.14366

The first forming galaxies: where are they now?

Supervisor: A/Prof Edward Taylor
Contact: entaylor@swin.edu.au

Project description: One of the biggest puzzles in galaxy formation and evolution is the existence of very massive galaxies in the very early Universe. There are many aspects to this puzzle: it's a surprise that they can assemble so much mass so quickly; it's a surprise that something seems to have cut off their star formation; it's doubly surprising that they seem to have sizes that are 1/10th the size of similarly massive galaxies in the present day Universe. The implication is that, in order to grow into the kinds of galaxies we see in local Universe, these galaxies have to grow considerably in size, but without growing very much in mass, and we don't really understand how this might be possible. The aim of this project is to use new data from the Galaxy And Mass Assembly (GAMA) survey to find the local Universe counterparts to these first forming galaxies. What we will do is take spectral velocity dispersion measurements, which are a measure of the gravitational potential at the centre of galaxies, as a way to make the evolutionary link between galaxy populations from the earliest times back to the here and now.

Further reading:

- https://arxiv.org/pdf/2012.09175.pdf

A new tool for galaxy survey science

Supervisor: A/Prof Edward Taylor
Contact: entaylor@swin.edu.au

Project description: A basic challenge of observational astronomy is that you can rarely measure the thing you are really interested in; instead, you have to find clever ways to infer the true state of affairs based on what you can actually observe. One simple example is using distance to go from how big or bright something appears to how big or bright it really is. The central problem in this project is de-redshifting. Redshifting refers to the light from distant galaxies is being observed at redder wavelengths, because of the way that photons get caught up in the expansion of the Universe. This means that when we observe galaxies at different distances/redshifts, we are actually measuring different parts of their intrinsic spectrum: for an apples-to-apples comparison of galaxies colours or luminosities we have to account for this effect. In the past, I have written some terrible code to do this kind of calculation. The goal for this project is to do this job properly: i.e. to write good code (including some algorithmic improvements) and to produce a common user utility that can be used by future galaxy survey projects. If you have or want to develop good scientific programming skills, then this project is for you!

Further reading:

- https://arxiv.org/abs/0903.3051

Optical Site Testing for Robotic Telescopes

Supervisor: Prof Karl Glazebrook
Contact: kglazebrook@swin.edu.au

Project description: Demand for future optical observing facilities dedicated to survey and fast response trigger follow up is only likely to increase. One such facility is the Gravitational wave Optical Transient Observer (GOTO), a project which is hoped eventually to consist of a pair of instruments, one in La Palma, Canary Islands, and one in Australia. Analysis of meteorological and elevation data from across Australia has revealed potentially the best optical observing site on the continent, in the Hamersley Range in northwest Western Australia. This project involves working with a special a special lightweight telescope and high frame rate camera we have assembled which is designed to be transported to remote sites and measure seeing. Goals:

- Develop improved analysis code and automate based on current software stack and existing on-sky test data.

- Transport telescope to dark sites around Victoria and further around Australia to greatly expand the dataset and externally validate the method, including possibly the Hamersley range if things go well. This would result in a publication demonstrating about seeing measurement and site quality.

This project is most suitable to students who like to get their hands dirty with small telescopes and have a taste for outdoor adventure in science. The project would be in collaboration with Prof. Roberto Abraham and Professor Duncan Galloway of Monash and could lead to commercial applications ('Southern Hemisphere Seeing Monitor').

Further reading:

- Hotan C. E., Tingay S. J., Glazebrook K., 2013, Testing Potential New Sites for Optical Telescopes in Australia, Publications of the Astronomical Society of Australia, 30, e002.