CAS HONOURS PROJECT LIST 2026

How Do Exploding Stars Reshape Galaxy Evolution

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

Project description: In starburst galaxies, clusters of supernovae explode in the disk, the combined energy and momentum pushes gas up out of the spiral galaxy and into the halo above the disk. This changes the properties of the galaxy, and is considered by most theories to be a linchpin that regulates the growth of galaxies. We view this as faint filaments of gas that extends above star forming galaxies. In this project we will study this gas. The physical properties of the gas directly relate to the physical models of how these large outflows of gas evolve and shape outflows. We will use data from the Keck 10m optical telescope and the VLT 8m telescope to study the outflowing gas. At Swinburne you will work in a team of other PhD students and postdocs, along with myself, and be part of an international team through regular meetings.

Further reading:

- Galactic Winds Dictating Galaxy Evolution – 20 min Lecture by L. Zscaechner https://www.youtube.com/watch?v=hqpLWgRMdw0
- How Feedback Shapes Galaxy Evolution – 1 hour lecture by Prof Christy Tremonti https://www.youtube.com/watch?v=ODZ_dfe2r7I

Finding new radio pulsars in an extragalactic globular cluster using the MeerKAT telescope

Supervisor: Dr Emma Carli
Contact: ecarli@swin.edu.au

Project description: Pulsars are "dead" collapsed stars that are amongst the most extreme objects of the Universe - they are the fastest spinning stars (usually, they undergo one complete revolution in less than a few seconds); they are the smallest and densest stars, with approximately the mass of our Sun contained in a radius of a few tens of kilometres; and they have the strongest stellar magnetic fields. Their lighthouse-like radio beams are observed as faint radio pulses from the Earth. While well over 3000 pulsars have been found in the Milky Way, our own galaxy, only about 40 extragalactic pulsars have been found due to their distance. In this project, you will use a dataset from the state-of-the-art South African radio telescope MeerKAT to search for some of the fastest-spinning and relativistic pulsars outside of our galaxy.

Axion Dark Matter Detection

Supervisor: Dr Ben McAllister
Contact: bmcallister@swin.edu.au

Project description: The nature of dark matter is one of the biggest mysteries in modern science – it makes up five sixths of the matter in the Universe, and is of unknown composition. It surrounds and passes through the Earth at all times. Axions are a hypothetical particle, and one of the leading candidates for dark matter. Swinburne is building a new axion detector to try and measure small effects induced by dark matter when it passes through the laboratory, and shed light on the mystery. The kind of experiment we are building is called an axion haloscope. The detector is being physically constructed and will be hosted at Swinburne – but work needs to be done on various aspects of the project, from detector characterisation, to control software and data analysis, including machine learning. This project could focus on any of these areas, tailored to fit the skills and interests of the student. There is room for multiple students, and you will be working in a small team with other researchers. You may be working with laboratory equipment, on code to control the experiment, or on a pipeline to acquire and tease through experimental data for hints of new physics using new data analysis techniques.

Examining the Circumgalactic Medium Around Galaxies

Supervisor: Prof Glenn Kacprzak
Contact: gkacprzak@swin.edu.au

Project description: The circumgalactic medium (CGM) is the gaseous halo surrounding galaxies, playing a crucial role in galaxy evolution by regulating gas accretion and outflows. Despite its importance, the CGM remains poorly understood due to its diffuse nature and low density, making it challenging to detect and study. This project will involve analysing data from the Keck Telescope and other observatories to explore the physical properties of the CGM. You will use spectral line diagnostics to investigate the interactions between galaxies and their surrounding halos, focusing on how gas inflows and outflows impact galaxy growth and star formation. This work will help build a more complete understanding of how galaxies evolve over cosmic time.
You will develop skills in Python programming, data reduction, and visualisation while learning to work with astronomical datasets. The project may also involve comparing observations with theoretical models of the CGM, helping you gain a strong foundation in both observational and theoretical astrophysics.

Further reading:

- Tumlinson et al., 2017, *The Circumgalactic Medium*: https://arxiv.org/abs/1709.09180

Where Stars Die: Investigating Supernova Locations Across Galaxies

Supervisor: Dr Anais Möller
Contact: amoller@swin.edu.au

Project description: The Universe is constantly changing, shaped by short-lived but powerful events such as supernovae and bursts of radiation — collectively known as transients. Although fleeting, these phenomena offer valuable insights into extreme astrophysical processes and the underlying physics of the cosmos. In this project, you will work with data from the Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) — the most ambitious transient survey to date, expected to detect millions of transient events each night. Your task will be to identify and classify different types of supernovae, using Rubin LSST observations, and investigate how they are distributed across different environments. A key goal of this project is to understand why certain types of supernovae are more likely to occur in specific galactic environments — for example, whether they tend to explode near the centers of galaxies or in their outskirts. These environments include the host galaxies themselves as well as the location within each galaxy. As part of this project, you will join Fink, an international collaboration with real-time access to Rubin's alert stream, and will benefit from additional spectroscopic and multi-wavelength data to support your analysis.

Testing the variability of fundamental constants with quasar spectra

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

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 the existing telescopes, and the future 39-metre "Extremely Large Telescope" being built in Chile. These and a range of other possible options will be discussed with the candidate.

Further reading:

- Murphy M.T. et al., 2022, Astronomy & Astrophys, 658, A123 (arXiv:2112.05819)

Do Fast Radio Bursts stem from rotating Neutron Stars?

Supervisor: Dr Joscha Jahns-Schindler
Contact: jjahnsschindler@swin.edu.au

Project description: Fast Radio Bursts (FRBs) are intense, brief flashes of radio waves originating from distant galaxies. First discovered in 2006, they have generated significant excitement due to their mysterious origin, which still remains unresolved. About 5% of the ~1000 known FRBs show repeat bursts, while most are only seen once. The most promising source candidates are Magnetars – rapidly rotating neutron stars with the Universe's strongest high magnetic fields. The most direct way to prove this connection is by finding a periodicity in the burst arrival times. However, to many people's surprise, no periodicity has been observed in any of the 58 known repeating FRBs. Recently, a promising new method of periodicity searching has been proposed that uses the polarisation of the radio signal.
The interested student would use python to build their own periodicity search algorithm. They will then test their code on existing data of Galactic Rotating Radio Transients (RRATs). They would get the possibility to observe with Murriyang, the 64-m Parkes telescope, to detect their own RRATs or FRBs and search them for periodicities.

Further reading:

- Rajwade et al. 2025, https://arxiv.org/abs/2504.18176

Exploring the Bluest Galaxies in the Distant Universe with the JWST MINERVA Survey

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

Project description: The James Webb Space Telescope has uncovered some of the bluest galaxies ever seen, shining just a few hundred million years after the Big Bang. Their striking colours may come from hot, young stars, very low metallicity, little or no dust, or even leakage of ionising radiation that helped reionise the early Universe. In this project, you will use deep imaging from the MINERVA survey, which provides NIRCam medium-band and wide-band coverage over the Hubble Legacy Fields, to measure the UV slopes of these galaxies and figure out what makes them so blue.By combining UV slope measurements with models of dust, stellar populations, and metallicity, you'll test whether these galaxies are metal-poor starbursts, nearly dust-free, or leaking large amounts of Lyman-continuum photons. You'll gain hands-on experience with JWST imaging data, photometric analysis, and galaxy evolution models, while helping to uncover how the first generations of galaxies grew and transformed the Universe.

The Morphologies of Massive Galaxies and Their Environments at $4<z<10$ with MINERVA

Supervisor: Dr Nancy Kawinwanichakij
Contact: lkawinwanichakij@swin.edu.au

Project description: JWST has revealed populations of massive galaxies as early as $z>4$, including compact quiescent systems and larger star-forming disks. Understanding how their morphologies relate to local environment provides key insights into the earliest stages of massive galaxy assembly. In this Honours project, the student will analyse structural properties (sizes, Sérsic fits, and bulge-to-total ratios) of massive galaxies in the MINERVA survey, and investigate how these vary with environment. A particular focus will be the relation between size–mass–B/T and environment, testing whether dense regions are associated with more bulge-dominated or compact systems. In addition, the student will perform visual morphological classifications of a subsample of galaxies, providing an independent check on parametric fits and identifying unusual or disturbed systems. The student will be embedded in the JWST Australian Data Centre group (jadc.swin.edu.au), a team of ~ten scientists and PhD students at Swinburne studying the early Universe with JWST, providing strong support in both observations and analysis. This project offers the exciting opportunity to explore how the earliest galaxies were shaped by their environments and to contribute directly to ongoing JWST research.

Astronomy for Space Domain Awareness

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

Project description: Space Domain Awareness (SDA) refers to the tracking, monitoring, and identification of objects in space. That includes the 6000+ operational artificial satellites in Earth orbit, along with a staggering number of pieces of small debris (well over 100 million objects with sizes between 1 mm to 1 cm). This is an increasingly challenging, time-critical, and risky endeavour with potentially devasting consequences for access to space if an accident was to occur. Due to the rapid increase in the number of satellite launches, driven by the availability of low-cost commercial launch services and payloads, there is an urgent need to understand, improve or enhance SDA operations. As an Honours student joining Swinburne's Space Domain Awareness research group, you will investigate the role that international astronomy research facilities like the Vera C. Rubin Observatory can play in making space safe and sustainable. Based on your skills and interests, this project will rely on a combination of Data Analysis, Machine Learning, Advanced Visualisation, and Human-AI Teaming.