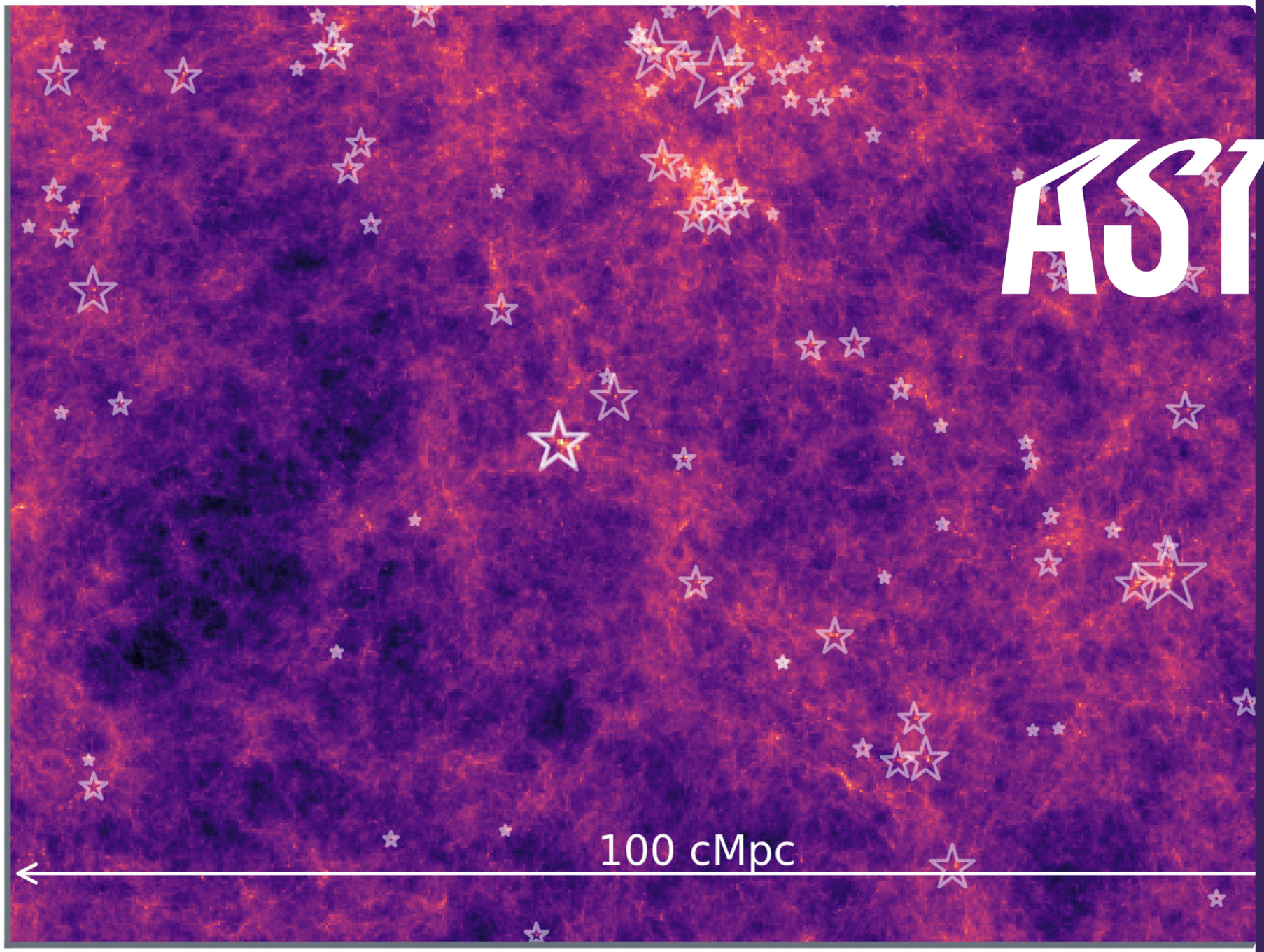


ASTRO 3D

AUSTRALIAN RESEARCH COUNCIL
CENTRE OF EXCELLENCE FOR ALL SKY
ASTROPHYSICS IN 3 DIMENSIONS

2023 ANNUAL REPORT

Australian Government
Australian Research Council

CONTENTS

Image on front page: The density field at z=8 overlapped with the distribution of bright galaxies predicted by the Meraxes semi-analytic galaxy formation model, illustrating brighter galaxies are often located in over-dense regions. (Yuxiang, Q et al. MNRAS, 510, 3)

GOVERNANCE

EXECUTIVE MANAGEMENT COMMITTEE

The Executive Management Committee works collaboratively to oversee day-to-day operations, including financial and risk management, the development of the strategic plan and monitoring performance against agreed outcomes. All collaborating universities are represented on the committee.

Director | Prof. Stuart Wyithe (UMelb) and Prof. Emma Ryan-Weber (Swinburne)

Deputy Director | Prof. Cath Trott (Curtin)

Chief Operating Officer | Ms Ingrid McCarthy (ANU)

Node Leaders | A/Prof. Emily Wisnioski (ANU), Prof. Scott Croom (USyd), A/Prof Amanda Karakas (Monash), Prof. Richard McDermid (Macquarie), Prof. Chris Power (UWA), A/Prof. Deanne Fisher (Swinburne), A/Prof. Kim-Vy Tran and A/Prof. Sarah Martell (UNSW), Prof. Michele Trenti (UniMelb), Prof. Cathryn Trott (Curtin)

Collaboration Leader | Prof. Joss Bland-Hawthorn (Sydney)

COMMITTEE LEADS

Equity, Diversity and Inclusions (EDI) | A/Prof. Kim-Vy Tran (UNSW) and Dr Tayyaba Zafar (Macq)

Junior Early Career Researchers (ECRs) | Dr Stefania Barsanti (ANU)

Senior Early Career Researchers (ECRS) | Dr Sven Buder (ANU)

Students | PhD Student Marcie Mun (ANU)

Black Lives Matter (BLM) | Krystal de Napoli (Swin)

ADVISORY BOARD

The Advisory Board meets at least annually to provide support and advice to the Director and Executive Committee on the effectiveness of the Centre in reaching its scientific, technical, and operational goals.

Chair | Professor Anne Green

Members | Dr Linda Tacconi (Max Planck Institute for Extra-terrestrial Physics), Prof. Lars Hernquist (Harvard-Smithsonian Centre for Astrophysics), Sue Weston (AAL Director), Dr Bobby Cerini (Deputy Director, Director of Science and Learning at Questacon) and Prof. Mary Putman (Columbia University).

ASTRO 3D Director Prof. Emma Ryan-Weber and Deputy Director Prof Cath Trott. Credit: Cristy Roberts

COLLABORATING UNIVERSITIES

Australian National University
Curtin University
Macquarie University
Monash University
Swinburne University of Technology
The University of Melbourne
UNSW Sydney
The University of Sydney
The University of Western Australia

PARTNER INSTITUTIONS

ASTRON Netherlands Institute for Radio Astronomy
California Institute of Technology
Chinese Academy of Sciences
CSIRO
NCI Australia
University of Hertfordshire UH
University of Oxford
University of Toronto
University of Washington

Acknowledgement

ASTRO 3D acknowledges the support of the Australian Research Council and all of the collaborating and partner institutions in the Centre.

OUR STRATEGIC GOALS

BUILD

Build and maintain the infrastructure, skills and expertise required to maximise Australia's investment in the new era of mega-scale optical and radio telescopes through our research programs, skills workshops, mentoring, leadership and succession planning. We will train young Australian scientists to drive the future world-leading programs on the next generation of telescopes.

TRANSFORM

Transform our understanding of the Universe and how we got here. We will conduct ground breaking new 3-Dimensional surveys alongside an observationally-driven theory program with dedicated telescope and supercomputing facilities.

CREATE & INSPIRE

Create an innovation culture to facilitate the transfer and commercialisation of astronomical technology to other disciplines by identifying fresh ideas and aiding the commercialisation of new astronomical technology through our Intellectual Property and Innovation Committee.

Inspire, train and mentor the next generation of diverse Australian scientific leaders. We will inspire students to study science, technology, engineering and mathematics (STEM) through new teacher education programs and our ambitious nation-wide public outreach campaigns.

NEXT GENERATION

Provide young Australian scientists with transferable skills for the modern workforce by training the new generation of young Australian astrophysicists in transferable skills including data intensive science.

Provide a broad range of career options outside astrophysics including market analysis, population statistics, medical science, bioinformatics, genomics, and commercial sector data analytics.

ABOUT ASTRO 3D

The ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D) commenced in July 2017 and is a Research Centre of Excellence led by the Australian National University (ANU) from its Research School of Astronomy and Astrophysics at Mt Stromlo.

The Centre is comprised of nine collaborating universities: Australian National University, the University of Melbourne, the University of Sydney, Swinburne University of Technology, the University of Western Australia, Curtin University, Monash University, the University of New South Wales and Macquarie University — and a number of world-class Australian and international partners, including:

California Institute of Technology, USA (Caltech)

Chinese Academy of Sciences (CAS)

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

National Computational Infrastructure (NCI)

Netherlands Institute for Radio Astronomy (ASTRON)

University of Hertfordshire, UK

University of Washington, USA (UW)

University of Toronto, Canada

University of Oxford, UK

The Centre has been funded over seven years with a $30.3m grant from the Australian Research Council (ARC), $9.995m in cash from the nine Australian universities and $134m of in-kind resources from across the collaborating and partner institutions.

OUR VISION

To unlock the mysteries of the Universe using innovative 3D technology, while sharing the excitement and wonder of astronomy to inspire the broader community.

OUR MISSION

To propel Australia to the forefront of astronomical research by combining Australia's radio, optical and theoretical expertise to understand the origins of our Universe and the galaxies within it.

To train future Australian astronomers to lead breakthrough science on the next generation of telescopes.

To share our discoveries and passion for research with the broadest possible audience and inspire the scientists of the future.

WHY ASTRO 3D?

The most fundamental question in astrophysics, "How did we get here?", covers vast ground - from the Big Bang and the stars that first lit the cosmos, to the evolution of the diverse Universe that surrounds us today. No single telescope or theoretical simulation can answer this question. This problem requires new panchromatic all-sky surveys that cover thousands of square degrees of sky to capture the light from hundreds of thousands of galaxies.

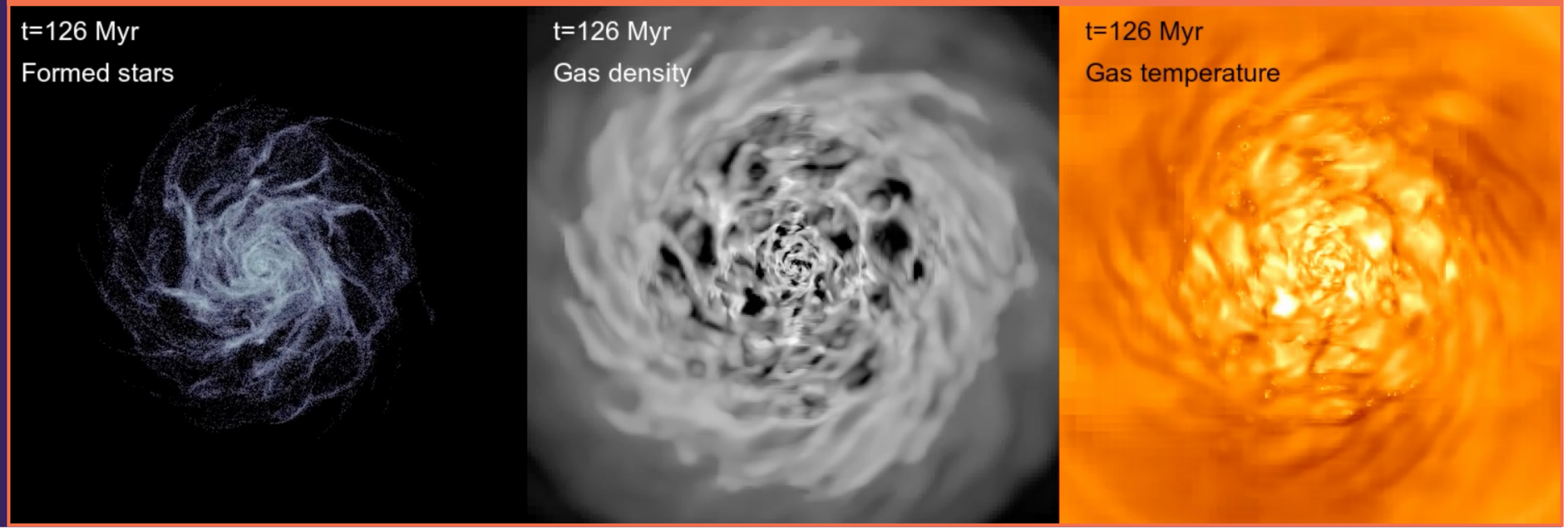
Critically, it also requires 3D; the extra dimensions of time and motion are required in addition to the typical space or frequency dimensions in previous surveys. Using new 3D Integral Field Technology (IFU) for every pixel of light we receive from a telescope, we can generate a datacube, that gives us information about:

- spatial properties (what is where)
- spectral properties (what chemical elements are present)
- velocity information (are the stars and the gas moving away from us or towards us)

ASTRO 3D strategically combines new 3D radio, optical, and infrared technology with new supercomputing infrastructure. 3D surveys allow us to track how the different phases of matter, neutral hydrogen gas, ionised gas, stellar mass, and dark matter accumulated and spread across the history of the Universe.

As a consequence of this cutting-edge 3D data and modelling, ASTRO 3D will be able to utilise tools such as virtual reality, 3D movies, 3D printed models and files, coupled with links to school curriculum to help both the general public and students understand and appreciate the new era of discovery in astrophysics.

Image Below: N-body/hydrodynamical simulations of isolated, gas-rich, star-forming galaxies, aimed at understanding the properties of primeval galaxies in the early Universe. The high gas surface densities encourage vigorous star formation, which in turn couples with the gas to drive turbulence self-consistently. fd50_fg20_nac at standard resolution. Evolution of the galaxy on a face-on projection. Left: Newborn stars. Centre: Gas density. Right: Gas temperature. Simulation by Thor Tepper-Garcia (USyd)



DIRECTOR'S WELCOME AND REPORT

In 2023 we entered the final two years our research centre and began to reflect on our overarching scientific goals.

We have made successful in-roads towards understanding how our Universe evolves. ASTRO 3D has indeed produced a comprehensive picture of the evolution of matter, the chemical elements, and energy in the Universe, from shortly after the Big Bang, to the present day.

Neutral atoms in the Universe became ionised (lost their electrons) due to the intense radiation from the first stars and galaxies. The Murchison Widefield Array (MWA) is getting closer to detecting the elusive radio wave signal from the early Universe that will reveal when the fog of neutral hydrogen gas was lifted. The observations provide critical input to theoretical simulations that predict the nature of the early Universe. Utilising JWST, our researchers have compiled the largest survey of galaxy properties during the peak of the reionisation period to establish that these galaxies started ionising the Universe at very early times.

We have used 3D surveys that give us spectra for each pixel of light using optical and radio telescopes, to understand the accumulation of matter in the Universe over time. SAMI has been a game changer for studying why the stars in some galaxies rotate together in a nice, ordered manner, whilst the stars in other galaxies seem to have been thrown together in a jumbled mess. AGEL spectroscopy allowed us to map a 3D picture of the gravitational lenses to show they are genuine, and not merely chance, superposition, revealing the underlying dark and atomic matter. Our cosmological simulations show that big galaxies steal star-forming gas from their smaller neighbours.

ASTRO 3D's periodic table is a powerful tool that summarises the origin of the chemical elements, showing the processes by which each element is synthesised and its abundance over time (from the Big Bang to the present). We used theoretical models, observations of ancient gas clouds in the early Universe, and chemical tagging of present-day stars in the Milky Way to develop both the roadmap and the atlas of atomic elements. Among our discoveries is the most iron-poor star in the Milky Way, and the finding that the amount of warm carbon rapidly increased a billion years after the Big Bang.

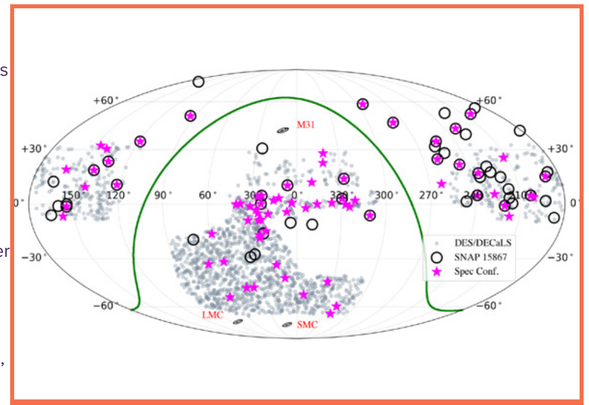
In April of 2023 our second director, Prof Stuart Wyithe took up the position of Director for the Research School of Astronomy & Astrophysics (RSAA) at ANU. Stuart had been interim Director for 12 months, as well as the inaugural deputy director working with Prof Lisa Kewley, who had been appointed as Director, Center for Astrophysics, Harvard & Smithsonian in 2022. Both Stuart and Lisa's appointments reflect the high esteem with which the leadership of ASTRO 3D is regarded in our national and international astronomical communities.

In early 2023 I was interviewed by the ARC as incoming ASTRO 3D Director. Viewed in isolation another change of Director could have looked unstable, but nothing could be further from the truth. Standing on the shoulders of two innovative, progressive and thoughtful leaders, I took on the role knowing that ASTRO 3D is an organisation that I am incredibly proud of, and would be a privilege to lead. The ARC has insightful knowledge of the workings of ASTRO 3D, and had no hesitation that our centre was in good shape! I took over as Director in April 2023. I would like to thank Prof Cath Trott who has continued as Deputy Director and the chair of our Science Management Committee, and our COO Ingrid McCarthy, and professional staff team who have all been incredibly supportive in the handover and running of the Centre. At the end of 2023, we said farewell to Ingrid, who accepted a position as COO for a new ARC industrial training centre for Radiation Innovation, commencing January 2024. We are thrilled for Ingrid and will miss her dearly! She has been the solid co-pilot of ASTRO 3D, having commenced in 2017 as the head of Education and Outreach, and promoted to COO in 2019.

The funding ASTRO 3D receives is invested in people: students, postdoc researchers and investigators. To achieve the very best science, it's imperative that we provide the very best workplace culture and career support for our scientists. The positive research culture in ASTRO 3D is a result of being able to come together at events like the annual science meetings and retreats. It's at these retreats we can reflect on how we go about our science, fostering a culture of respect and inclusion. The conversations we engage in around our training programs brings everybody on board to the wider goals of the Centre. Including all members in the education, outreach and media training sessions means that we're all across communication of our science. In 2023 we ran a focused professional development program for academic women leaders, had a keynote speaker on sustainability and climate action, active bystander training, support for attendance at the InSTEM conference and a training session on neurodiversity. Furthermore, our students and postdocs have been supported to explore career options in the wider community, transferring their astrophysics skills to solving real world problems.

One of the most powerful messages to take away from ASTRO 3D's gender parity is the importance of monitoring and evaluation. We have submitted our strategy to the Women in STEM evaluation portal and have participated in the department of Industry, Science & Resource's Diversity in STEM Review to further facilitate research centres in achieving gender parity.

Finally, I would like to personally thank professional staff Cristy Roberts, Delese Brewster and Kim Dorrell who have worked incredibility hard on putting together this annual report. Cristy is credited with capturing photos of people who are the very fabric of ASTRO 3D. This report culminates our scientific achievements and social progress.



Spatial distribution of candidate gravitational lenses in the DES/DECaLS fields (gray circles) and the 77 spectroscopic redshifts from our AGEL survey (pink stars; Table 3) where the secured redshift is of the deflector (foreground) and/or the source (background). The confirmed gravitational lenses span a range in R.A., and most are at declinations near the equator and can be observed by telescopes in both hemispheres; the plane of the Milky Way is shown as the green curve. Several of the confirmed strong lenses are targeted in the HST SNAP program #15867 (open black circles) that provides the high-angular-resolution imaging needed to model the gravitational lenses; additional HST imaging of AGEL systems is ongoing in Cycle 29 (#16773) Kim-Vy H. Tran et al 2022 The Astronomical Journal 164

Emma Ryan-Weber with Girls in STEM student leader Eleanor Justin, featuring the ASTRO 3D Periodic Table Poster in the background. Targeted programs such as the one run by the Ballarat Tech School provide role models, experience and skill development for aspiring young women.

PROFESSOR EMMA RYAN-WEBER

Emma Ryan-Weber is a Professor in Astrophysics at Swinburne University of Technology. Ryan-Weber's research focus is on the earliest elements in the Universe and how they have evolved over cosmic time. She pursues this work within ASTRO 3D as part of the Centre's Galaxy Evolution Program. Ryan-Weber leads the metal absorber science for the European Southern Observatory (ESO) VLT Large Program, XQR-30. The program is the most ambitious to date for follow-up spectroscopy of redshift 6 quasars, used to probe intervening elements such as carbon and oxygen.

Ryan-Weber obtained her PhD from the University of Melbourne in 2004. She was appointed as a postdoctoral Fellow at the University of Cambridge working on number of cutting-edge projects including star formation between galaxies and the discovery of the Milky Way's faintest gas-rich dwarf companion. Ryan-Weber's pioneering observations using near-infrared spectroscopy revealed the most distant carbon detected in the intergalactic medium. She is a sought-after international speaker on the subject.

In 2009 Ryan-Weber returned to Australia and commenced a position at Swinburne's Centre for Astrophysics and Supercomputing, where she held an Australian Research Council Queen Elizabeth II Fellowship. As a research group leader Ryan-Weber mentors her PhD graduates and postdoctoral researchers to pursue careers in both astrophysics and industry, creating impact in the wider community.

AWARDS, PRIZES AND GRANTS

AWARDS

Chief Investigator Professor Matthew Colless (ANU) was appointed an Officer of the Order of Australia for '*distinguished service to scientific research, particularly to astronomy and astrophysics, and to professional societies*'.

Associate Investigator Professor Naomi McClure-Griffiths (ANU), was named by Cosmos Magazine, as one of the 50 women at the cutting edge of science in Australia for her expertise on the atomic hydrogen gas distribution and evolution of the Milky Way and its neighbours, the Magellanic Clouds

Chief Investigator Professor Joss Bland-Hawthorn (UniSyd) was elected International Honorary Member of the American Academy of Arts and Science, a rare honour that only a small number of Australians have received. Read More.

Professor Bland-Hawthorn (UniSyd) was ranked #204 in the world and #1 in Australia by Research.com (an academic platform for researchers) for 'Best Scientists' in the field of Physics for 2023. Joss has also been recognised with Research.com's Physics Leader Award for 2023. ASTRO 3D AI Prof. Karl Glazebrook (Swinburne) was ranked #3 and CI Prof. Matthew Colless (ANU) was ranked #7 in Australia. The full world ranking is available here and the full ranking for Australia is available here.

Chief Investigator Professor Elaine Sadler (UniSyd) was elected as a Fellow of the Royal Society of NSW in recognition for her 'international reputation in the field of galaxy evolution and astrophysics'.

PRIZES

Charlene Heisler Prize | Dr Piyush Sharda (ANU) 'The role of metals from molecular clouds to galactic discs'.

Louise Webster Prize joint winners | Dr Nichole Barry (Curtin) 'Improving the Epoch of Reionization Power Spectrum Results from MWA Season 1 Observations' Barry, et. al. (2019b) ApJ, 884, 1; and Dr Sven Buder (ANU) 'The GALAH+ survey: third data release' Buder *et al.* (2021) *MNRAS*, 506, 150

Anne Green Prize | A/Prof Michelle Cluver (Swinburne) for 'contributions to the understanding and characterisation of galaxies in the infrared, through the WISE survey, and significant novel contribution to the field of galaxy evolution, specifically in demonstrating the power and versatility of WISE mid-infrared imaging to elucidate star formation history, the role of mass quenching, and the effect of environment, in galaxy groups'.

Emerging Leaders in Astronomy Software Development prize | Dr Manodeep Sinha (Swinburne) for CORRFUNC – an open-source high-performance code to compute correlation functions extremely quickly.

ASTRO 3D Students who won prizes and honourable mentions at this year's Astronomical Society of Australia's Annual Scientific Meeting (ASA ASM). Prizes and winners included:

Best Student Talk | PhD student Ben Metha (UniMelb) for his talk on 'Geostatistics of Galaxies: A novel approach to understand multiscale metallicity variations'.

Best Student Talk 2nd Place | PhD student Maddie Mackenzie (ANU)

Best Poster Prize | PhD student Giulia Cinquegrana (Monash)

Honourable Mentions | PhD students Kirsten Banks (UNSW), Maddy Howell (Monash) and Nicolò Dalmasso (UniMelb)

GRANTS

Discovery Early Career Researcher Awards (DECRAs)

- Associate Investigator Dr Nichole Barry (Curtin)
- ASTRO 3D PostDoc Dr Sven Buder (ANU)
- ASTRO 3D PostDoc Dr Rebecca Davies (Swin)
- ASTRO 3D PostDoc Dr Yuxian Qin (ANU/UniMelb)

Associate Investigator Dr Tayyaba Zafar (Macq) was awarded a $50k Macquarie University Research Acceleration Scheme (MQRAS) grant to support her research on dust properties connected with the MAGPI Survey.

ASTRO 3D Postdoc Dr Stefania Barsanti (ANU) was awarded an ECR international travel grant from ANU.

TELESCOPE TIME AWARDED

ANU PhD student Madeleine McKenzie (ANU) was awarded 15 hours as Principle Investigator on the VLT/UVES+FLAMES.

The AGEL team was successfully awarded highly competitive James Webb Space Telescope (JWST) (led by ASTRO 3D Postdoc Dr Tania Barone) and Hubble Space Telescope (HST) (led by Affiliate A/Prof. Vy Tran) time to follow up gravitationally lensed galaxies. ASTRO 3D success is celebrated with CI and Melbourne Uni Node Leader Prof. Michele Trenti as Co-PI of an approved Pure Parallel imaging survey with JWST cycle.

AI Prof. Karl Glazebrook was awarded time for his large 3D Spectroscopic Pure Parallel Survey, which will form part of his Laureate Fellowship program.

CI Prof Julia Bryant (UniSyd) and the Hector team were ranked number 1 in the last round of AAT proposals.

PhD student Simon Ho (ANU) had his Five Hundred Metre Aperature Spherical Telescope (FAST) proposal accepted.

Affiliate Dr Andrew Battisti (ANU) and the MAGPI team had their HST proposal accepted. This program will image 11 MAGPI fields in four WFC3/UVIS filters (F225W, F275W, F336W, F390W) over 33 orbits (21.25hr science time).

The ASKAP FLASH team were also awarded observing time with the South African MeerKAT telescope, the Long Baseline Array (LBA) and the US VLBA and UK eMerlin VLBI arrays for follow-up observations of HI absorption-line systems detected in the Pilot Survey.

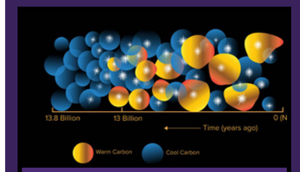
SCHOLARSHIPS

ASTRO 3D PhD student Ella Wang (ANU) was awarded one of the inaugural HPC-AI Talent Program Scholarships from the National Computational Infrastructure (NCI). The scholarship is designed to accelerate AI-enable research success for our next generation.

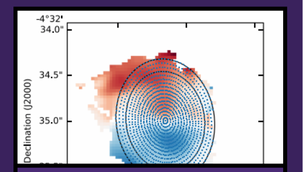
ASTRO 3D PhD student Giulia Cinquegrana (Monash) was awarded the 2023 CSIRO Alumni scholarship in Physics.

Images from left to right: CI Professor Matthew Colless pictured in Oxford. Inset: Officer of the Order of Australia Medal, ASTRO 3D Postdoctoral Researcher Dr Sven Buder giving his Louise Webster Prize talk. ASTRO 3D PhD student Giulia Cinquegrana pictured second from right with her CSIRO Alumni Physics Scholarship.

PRESS RELEASES

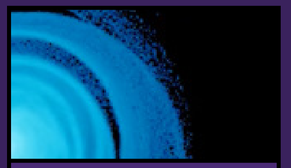


Tracing 13 billion years of history by the light of ancient quasars. Dr Rebecca Davies



Heat spots reveal growth rate of a galaxy 12 billion years ago. Dr Takafumi Tsukui

Gas-rich baby galaxies set the early universe alight. Dr Anshu Gupta



Astronomers detect seismic ripples in ancient galactic disk. Dr Takafumi Tsukui

ASTRO 3D CHIEF INVESTIGATORS

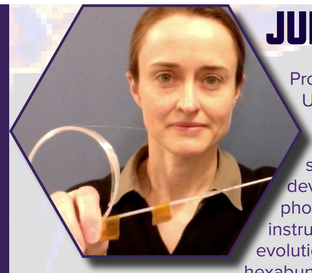
Leaders in their field of research, ASTRO 3D Chief Investigators (CIs) are responsible for the overall management of ASTRO 3D research projects and surveys.

JOSS BLAND-HAWTHORN

Professor Joss Bland-Hawthorn from the University of Sydney is an ARC Laureate Fellow renowned for innovative and broad-reaching science of both theoretical and observational astronomy, covering optical, infrared and radio wavelengths. Joss also develops instrumentation, having founded astrophotonics, playing key roles in the SAMI and HERMES instruments that are used in the SAMI and GALAH surveys.

Joss and his research team have used SAMI to explore how galaxy spin orientations correlate with the environment, how high-order kinematic components related to galaxies, and how slow rotator galaxies are distributed in the Universe.

Joss and his team are using the GALAH survey to trace the chemical and mass assembly history of the Milky Way. Joss is untangling the many complex processes involved in shaping a typical spiral galaxy like ours. Joss is the ASTRO 3D GALAH Survey lead and the ASTRO 3D Collaboration lead.



JULIA BRYANT

Professor Julia Bryant from the University of Sydney is an extragalactic astronomer and astronomical instrumentation specialist. She is an expert in the development and integration of photonic devices into astronomical instrumentation in order to study the evolution of galaxies. She developed the hexabundle technology underpinning the SAMI instrument, was a founding member of SAMI and led the target selection for the SAMI Survey. Her research focusses on how gas is accreted into galaxies to fuel star formation and the growth of galaxies of different morphologies and kinematics.

Julia heads up the Hector project, including the build of the Hector instrument and the Hector Galaxy Survey. The Hector Galaxy Survey is currently taking spatially resolved spectra of galaxies in the nearby Universe, and over the next 6 years will amass a sample of 15,000 galaxies.

She is Director of the University of Sydney node, one of three nodes, of Australia's astronomical instrumentation consortium, Astralis, which built Hector.

BARBARA CATINELLA

Professor Barbara Catinella from the University of Western Australia is an expert in multi-wavelength studies of cold gas in nearby galaxies. Her main research interest is understanding the gas-star formation cycle in galaxies and its connection with their local environment and cosmic web. She led state-of-the-art radio surveys that provided the deepest observations of cold gas in the local Universe, uniquely probing the vastly unexplored gas-poor regime and yielding strong constraints to theoretical models and simulations of galaxy evolution.

Barbara is co-PI of of the ASKAP WALLABY survey, which will provide the largest census of atomic hydrogen in the nearby Universe, and of the MAUVE survey, a large program with the MUSE instrument on the Very Large Telescope to unveil the physical processes responsible for quenching the star formation in cluster galaxies. These are both exciting, ongoing surveys that are producing amazing data -- get in touch if you would like to be involved!

MATTHEW COLLESS

Professor Matthew Colless from the Australian National University has made major contributions to astronomical research in the fields of galaxy evolution, clusters of galaxies, the large scale structure and motions of galaxies, and observational cosmology. As part of ASTRO 3D, he is leading a research team using the SAMI and Hector instruments to investigate the dynamical structure of galaxies and the accretion of angular momentum, and how these affect their star formation histories and stellar populations.

Matthew has served as the ASTRO 3D Node leader for the ANU and also Director of the ANU Research School for Astronomy and Astrophysics. RSAA provides some of the Centre's key facilities, through the wide-field optical capabilities of the ANU-owned SkyMapper Telescope and the ANU-operated Anglo-Australian Telescope.

SCOTT CROOM

Professor Scott Croom is from the University of Sydney and brings over a decade of experience leading large spectroscopic surveys to ASTRO 3D.

Scott leads the SAMI Survey and plays a major role in the Hector survey. SAMI results include new insights into galaxy scaling relations, the discovery of outflows in star-forming galaxies, and greater understanding of the formation mechanism behind dispersion-dominated galaxies. Scott is also the University of Sydney Node Leader for ASTRO 3D.

SAMI was replaced by the Hector instrument during 2022. Hector will survey 15,000 galaxies within a five year period and be significantly faster than SAMI. Scott is also facilitating collaborations with the Genesis team to compare the theoretical star-formation history of galaxies with observation.

DARREN CROTON

Professor Darren Croton from Swinburne University of Technology is an internationally-known theoretical astrophysicist who works on the formation of galaxies in the nearby and distant Universe. He conducts massive cutting-edge supercomputer simulations and mines large observational data sets from some of the world's largest telescopes. He is the ASTRO 3D Co-lead of the Genesis Simulations Thread.

Darren is using his extensive experience working as a theorist within large survey teams to lead the development of new galaxy formation models. These models will be applied to the interpretation of the vast amounts of data ASTRO 3D astronomers will have on hand across the Centre.

Darren will also assist the Data Intensive Astronomy team to create a single, cohesive interface where astronomers can query both the Genesis Simulations and the observational data simultaneously.

DEANNE FISHER

Associate Professor Deanne Fisher is based at Swinburne University of Technology. She received her PhD from the University of Texas in 2010. Deanne has since been a CARMA Research Fellow, Swinburne Director's Fellow and ARC Future Fellow. She is an Associate Professor in the Centre for Astrophysics and Supercomputing.

Her research focuses on multiwavelength studies of galaxies from the very nearby Universe at z=0 to galaxies just emerging from Reionisation at z=5. Deanne works in detailed observations spanning from UV observations, common use of Hubble Space Telescope and 10 m Keck and VLT optical telescopes and further to infrared and radio interferometry.

Along with a career in research she has been awarded for her efforts in equity and diversity, not just in astronomy, but within the national academic sector. She is among the founding members of the first nationwide, Australian LGBTQI support organisation for scientists.

AMANDA KARAKAS

Associate Professor Amanda Karakas from Monash University is a leading expert in the field of theoretical stellar evolution and nucleosynthesis for low and intermediate-mass stars, and on the impact of these stars on the chemical evolution of galaxies. In particular, she specialises in the evolved phases of stellar evolution, which is when stars produce metals and heavy elements deep inside their interiors. In recent years she has concentrated on the production of elements heavier than iron, which are produced in low-mass stars via the "slow neutron capture process".

Within the GALAH project the chemical evolution models that utilise Amanda's predictions will be compared to the abundances of stars in the Milky Way Galaxy, and within the First Stars project her theoretical models can be directly compared to carbon enhanced metal-poor stars, which can result from binary mass transfer from an evolved companion. These comparisons improve our understanding of element formation at the earliest times.

Amanda is also the ASTRO 3D Monash Node Leader.

SARAH MARTELL

Associate Professor Sarah Martell from the University of New South Wales is an observational astronomer who specialises in Galactic Archaeology. Her research focuses on in the ages, chemical makeup, and orbits of stars in the Milky Way. Her major research contributions are in the area of chemical tagging, which connects a star's elemental abundance pattern to the environment it formed in, whether that is the Milky Way, a captured dwarf galaxy, or a globular cluster.

Sarah's team uses data from large stellar surveys including GALAH to map out the present-day properties of stars. They combine that information with simulations of galaxy formation to uncover the history of star formation, element creation, and galaxy mergers in the Milky Way. They also collaborate with the Galaxy Evolution Project to compare that history in our home galaxy against other spiral galaxies.

Sarah is a member of the GALAH Survey Executive Team and the UNSW Node Leader for ASTRO 3D.

RICHARD MCDERMID

Professor Richard McDermid from Macquarie University is an expert in the field of stellar dynamics and stellar populations in galaxies, and combining these to deconstruct galaxy formation histories. He has pioneered the use of integral field spectroscopy in this area, and developed new techniques to understand the archaeological record of stellar orbits and chemistry in galaxies beyond the Milky Way.

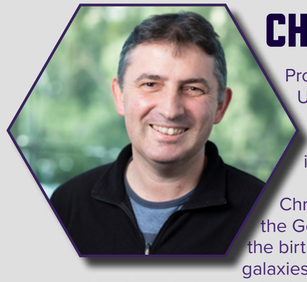
Richard leads the Macquarie University ASTRO 3D Node, and works closely with Data Central as part of the Data-Intensive Astronomy thread. He is also lead scientist for MAVIS – a major new instrument that Australia is developing for the European Southern Observatory that aims to build on the scientific legacy of ASTRO 3D.

MATT OWERS

Dr Matt Owers from Macquarie University is an extragalactic astronomer with extensive experience in using large-scale surveys to understand the impact of environment on galaxy properties. He is best known for his work on galaxy clusters at X-ray and optical wavelengths.

Matt has made significant contributions to the SAMI Galaxy Survey, where he led both the target selection and quenching-related science undertaken for the cluster portion of the SAMI galaxy survey. Matt is the Science Lead (Environments/ halos) for the Hector Galaxy Survey, and is also leading the target selection and characterisation of the cluster regions.

CHRIS POWER



Professor Chris Power from the University of Western Australia (UWA) is a computational astronomer who works on a broad range of problems in galaxy formation and cosmology.

Chris is leading the development of the Genesis Simulations that will track the birth, growth and the ultimate fate of galaxies from the earliest epoch of galaxy assembly, through the epoch of reionisation to the present-day. Chris is also the ASTRO 3D UWA Node Leader.

Chris' interests are in dark matter – what is its nature? What kinds of observations will allow us to discriminate between alternative models? And galaxy formation - how does feedback from stars and black holes (i.e. the deposition of energy and momentum into their surroundings) impact the formation and evolution of galaxies? He also has an interest in scientific high performance computing. Chris models large supercomputer simulations (comprising of ~100 billion particles) to construct the most detailed and sophisticated prescriptions for galaxy formation that we have.

ELAINE SADLER

Professor Elaine Sadler's research expertise covers both optical and radio astronomy and she has led several large radio surveys of the southern sky. She is a Professor of Astrophysics at the University of Sydney and also holds a part-time appointment as Chief Research Scientist at CSIRO Space and Astronomy. Within ASTRO 3D Elaine leads the 'Origin of Matter and Periodic Table' Theme and is co-leader of the 'ASKAP Surveys' project. She is co-PI of the ASKAP FLASH survey and also brings extensive science management experience.

Elaine is a Fellow of the Australian Academy of Science, and served as the Academy's Foreign Secretary from 2018-22. In 2019 she was appointed as an Officer of the Order of Australia (AO) for distinguished service to science as an astrophysicist in the field of galaxy evolution and to gender equality.

LISTER STAVELEY-SMITH

Professor Lister Staveley-Smith from the University of Western Australia (UWA) is the Interim Executive Director of ICRAR and has over two decades of experience in leading major surveys on new radio telescope facilities and in developing and applying new software and computation techniques.

Lister is co-leading the ASKAP HI Surveys project and is co-PI of ASKAP WALLABY project to image the southern sky in the 21-cm line of neutral hydrogen. Lister has also been co-leader of the Data Intensive Astronomy Program which facilitates the analysis of our petascale datasets, provides curation, visualisation and cross-linking capability for advanced data products, and provides the means to compare with theoretical models.

MICHELE TRENTI

Prof. Michele Trenti is the Director of the Melbourne Space Laboratory in the School of Physics at the University of Melbourne (Australia). He leads the Australia-Italy Space Industry Responsive Intelligent Thermal (SpIRIT) CubeSat mission, Australia's first space telescope, which was successfully launched in December 2023. SpIRIT is monitoring the sky for gamma and x-ray transients with an instrument provided by the Italian Space Agency, and it is demonstrating advanced Australian technology in orbit, with funding for mission development received by the Australian Space Agency. Prof. Trenti is an expert in a broad range of astrophysics research areas and has published more than 200 peer-reviewed journal articles, primarily based on - or related to - observations with space telescopes (Hubble, JWST and now SpIRIT). Prof. Trenti won over $12 million competitive research grants from multiple funding bodies in Australia and overseas as lead Chief Investigator, and has extensive experience in managing complex projects and leading international teams.

Prior to joining the University of Melbourne in 2014, he was a Senior Kavli Institute Fellow at the Institute of Astronomy, University of Cambridge (UK) from 2012 to 2014. After the PhD (2005) from Scuola Normale Superiore in Pisa (Italy), Prof. Trenti held postdoctoral positions in the USA at the Space Telescope Science Institute and at the University of Colorado, Boulder.

CATHRYN TROTT

Professor Cathryn Trott from Curtin University is ASTRO 3D Deputy Director and Curtin Node Leader. She is an observational radio astronomer using the current and expanded MWA and in the future, the SKA to explore the evolution of ionised hydrogen in the early Universe.

Cath is leading the ICRAR MWA Epoch of Reionisation (EoR) project for the Origin of the Ionised Universe Theme. Cath is using the supercomputing facilities at the Pawsey Centre and OzStar for EoR data storage, triage and analysis, augmented by existing and future-developed sophisticated signal processing algorithms. She is also assessing the scientific progress of the Centre against goals as part of the Science Management Committee, and developing her team with leadership and mentoring skills.

STUART WYITHE

Professor Stuart Wyithe is an international leading authority in the theoretical simulation of the Epoch of Reionisation and Gravitational Lensing and also currently the Director of the Research School School of Astronomy and Astrophysics at the Australian National University. Stuart's theoretical expertise spans the Epoch of Reionisation to first stars and galaxy formation and evolution, and he also brings important strategic planning experience to ASTRO 3D. Stuart is working closely with Chris Power to ensure the Genesis Simulations are incorporated with the Meraxes semi- analytic model infrastructure, and mock data are produced for the Centre's surveys.

His research interests lie in the field of quasar formation and reionisation in the early Universe. In particular, he is interested in the evolution of the earliest galaxies and how this evolution may be studied with the next generation of radio telescope.

RACHEL WEBSTER

Professor Rachel Webster is a Redmond Barry Distinguished Professor in the University of Melbourne School of Physics. She is an expert in the field of reionisation and is a member of the Board of Directors for Australian Astronomy Limited (AAL). She brings extensive leadership expertise to ASTRO 3D.

Rachel is co-leading the data reduction and analysis of the Epoch of Reionisation signals observed with the MWA. The improvement in the measured limits on the signal are allowing fundamental parameters of the Early Universe to be constrained.

Professor Webster's other research interests include quasar emission regions, gravitational lensing and cosmology; with a side interest in the physics of geothermal energy.

EMILY WISNIOSKI

Associate Professor Emily Wisnioski from the Australian National University specialises in studies of the interstellar medium and its evolution over cosmic time. She is a world-recognised expert on early star-forming galaxies. As a PI of the MAGPI Survey, a 340hr ESO MUSE Large Program, she is co-leading a group of 60+ researchers across Australia, Europe, Asia, and South America facilitating science across a range of key questions in galaxy evolution.

Emily's extensive experience utilising the facilities provided by VLT/ESO, in particular with spatially resolved spectroscopy, has led to her scientific leadership in a number of planned instrumentation projects on 8-30m class telescopes. As part of the near-infrared IFU KMOS3D survey at cosmic noon she led pioneering work on the turbulent evolution of marginally stable disk galaxies. Within the Galaxy Evolution thread, Emily is leading efforts to connect resolved kinematics and metallicity information at early times to local galaxies including studies of the Milky Way from the GALAH team.

ASTRO 3D MEMBERS

ASTRO 3D RESEARCH FELLOWS

are prestigious Post-Doctoral researchers who can develop their own research projects. Research Fellows are ASTRO 3D-funded early-career researchers who have completed their PhDs.

Name	Institution
Dr Katie Auchettl	University of Melbourne
Dr Kathryn Grasha	The Australian National University
Dr Anshu Gupta	Curtin University
Dr Nikki Nielsen	Swinburne University of Technology
Dr Sven Buder	The Australian National University
Dr Bradley Greig	University of Melbourne
Dr Kristan Boyett	University of Melbourne

PARTNER INVESTIGATORS (PIS)

are located at our Australian and international partner organisations (CSIRO, NCI, ASTRON, Caltech, CAS, Oxford, Toronto, Washington) and provide valuable research expertise, advice on research direction and world-class supervision of post-doctoral staff and students.

Professor Chiaki Kobayashi	University of Hertfordshire
Professor Baerbel Koribalski	CSIRO
Professor Raffaella Morganti	ASTRON - Netherlands Institute for Radio Astronomy
Professor Roger Davies	Oxford University
Professor Roberto Abraham	University of Toronto
Professor Andrew Bunker	Oxford University
Professor Bryan Gaensler	University of Toronto
Professor Di Li	CAS - Chinese Academy of Sciences
Professor Christopher Martin	Caltech - California Institute of Technology
Associate Professor Miguel Morales	University of Washington

PROFESSIONAL STAFF

support our researchers in the smooth running and promotion of the Centre.ASTRO 3D Professional Staff are Node Administrators and Education and Outreach Staff at both Central Administration (ANU) and our Nodes. Professional Staff are employed by ASTRO 3D at a Node university on a contract.

Mrs Cristy Roberts	The Australian National University
Mrs Maryse Papin	The Australian National University
Ms Lara Sharp	The Australian National University
Ms Ingrid McCarthy	The Australian National University
Dr Delese Brewster	The Australian National University
Ms Kim Dorrell	University of Melbourne
Mrs Marie Partridge	University of Sydney
Ms Clare Peter	University of Western Australia
Ms Tina Salisbury	Curtin University
Mr Ray Seikel	Swinburne University of Technology
Mr Simon Parsons	Swinburne University of Technology

EDUCATION AND OUTREACH AFFILIATES

are contributing to ASTRO 3D Education and Outreach Programs from their Non-Node home institution. They are independently funded professionals.

Mrs Leah Kalimeris	University of Western Australia
Ms Krystal De Napoli	Swinburne University of Technology
Dr Brad Tucker	The Australian National University
Mr Matthew Dodds	Farrer Agricultural College
Mr Peter Swanton	The Australian National University
Ms Karlie Noon	The Australian National University

ASSOCIATE INVESTIGATORS (AIS)

are senior researchers employed at one of our Node Universities and participating in ASTRO 3D research projects with specific deliverables. They make an intellectual and strategic contribution to ASTRO 3D in their specific area(s) of expertise.

Dr Claudia Lagos	University of Western Australia
Dr Nichole Barry	Curtin University
Dr Joanne Dawson	Macquarie University
Associate Professor Gayandhi De Silva	Macquarie University
Dr Bi-Qing For	University of Western Australia
Dr Caroline Foster	University of NSW
Professor Virginia Kilborn	Swinburne University of Technology
Dr Karen Lee-Waddell	University of Western Australia
Emily Levesque	University of Washington
Professor Naomi McClure-Griffiths	The Australian National University
Jessica Werk	University of Washington
Dr Elizabeth Mahony	CSIRO
Professor Jean Brodie	Swinburne University of Technology
Dr Devika Kamath	Macquarie University
Dr Tayyaba Zafar	Macquarie University
Dr Manisha Caleb	University of Sydney
Associate Professor Michelle Cluver	Swinburne University of Technology
Dr Michael Hayden	University of Sydney
Associate Professor Michael Brown	Monash University
Professor Luca Casagrande	The Australian National University
Associate Professor Andy Casey	Monash University
Mr Boquan Chen	The Australian National University
Xuelei Chen	CAS - Chinese Academy of Sciences
Dr Andrew Connolly	University of Washington
Professor Jeff Cooke	Swinburne University of Technology
Professor Luca Cortese	University of Western Australia
Professor Alan Duffy	Swinburne University of Technology
Professor Christoph Federrath	The Australian National University
Professor Karl Glazebrook	Swinburne University of Technology
Dr Brent Groves	University of Western Australia
Associate Professor Duane Hamacher	University of Melbourne
George Heald	CSIRO
Associate Professor Glenn Kacprzak	Swinburne University of Technology
Professor Mark Krumholz	The Australian National University
Dr Angel Lopez-Sanchez	Macquarie University
Dr Martin Meyer	University of Western Australia
Dr Chandrashekar Murugeshan	CSIRO
Dr Thomas Nordlander	The Australian National University
Associate Professor Danail Obreschkow	University of Western Australia
Tom Quinn	University of Washington
Dr Christian Reichardt	University of Melbourne
Dr Aaron Robotham	University of Western Australia
Associate Professor Lee Spitler	Macquarie University
Dr Jesse van de Sande	University of NSW
Dr Adam Watts	University of Western Australia
Associate Professor Randall Wayth	Curtin University
Professor Daniel Zucker	Macquarie University
Professor Dennis Stello	University of NSW
Professor Kenneth Freeman	The Australian National University
Professor Gary Da Costa	The Australian National University
Associate Professor Yuan-Sen Ting	The Australian National University
Dr Simon O'Toole	Macquarie University
Professor Richard de Grijs	Macquarie University
Dr Henry Zovaro	The Australian National University
Dr Jon Mendel	The Australian National University
Mx Dev Null	Curtin University
Dr Tobias Westmeier	University of Western Australia
Dr Aditi Vijayan	The Australian National University
Dr Ashley Ruiter	University of NSW
Dr Taissa Danilovich	Monash University

POSTDOCTORAL RESEARCHERS

are Early-Career Researchers (ECRs) who have completed their PhDs and are working on an ASTRO 3D Project or Survey. They also have cross-node Collaboration supervision and are funded by ASTRO 3D and employed on a contract at a Node university. They are supervised by more senior staff on our projects/surveys.

Dr Tania Barone	University of NSW
Dr Rebecca Davies	Swinburne University of Technology
Dr Stefania Barsanti	The Australian National University
Dr Madusha Gunawardhana	University of Sydney
Dr Ridhima Nunhokee	Curtin University
Dr Christopher Jordan	Curtin University
Dr Jack Line	Curtin University
Dr Bart Pindor	University of Melbourne
Dr Manodeep Sinha	Swinburne University of Technology
Dr Sam Vaughan	Macquarie University
Dr Yuxiang Qin	University of Melbourne
Dr Aditya J N H S	University of Sydney
Dr Takafumi Tsukui	The Australian National University
Dr Fan Liu	Monash University
Dr Nandini Sahu	University of NSW
Dr Ioana Ciuca	The Australian National University
Dr Mina Pak	Macquarie University
Dr Barbara Mazzilli Ciraulo	Swinburne University of Technology

ASTRO 3D AFFILIATES

are independently-funded researchers contributing to the research activities of the Centre, in collaboration with Chief, Partner and Associate Investigators.

Dr Amelia Fraser-McKelvie	University of Western Australia
Mrs Bronwyn Reichardt Chu	Other
Dr Elisabete da Cunha	University of Western Australia
Dr Hyein Yoon	Other
Dr Dorota Bayer	Swinburne University of Technology
Professor Sarah Brough	University of NSW
Professor Julianne Dalcanton	Flatiron Institute's Center for Computational Astrophysics (CCA)
Dr Katherine Harborne	University of Western Australia
Dr Anne Hutter	University of Copenhagen
Dr Meridith Joyce	Space Telescope Science Institute, Baltimore USA
Ms Melanie Klara Kaasinen	Max Planck Institute for Astronomy
Professor Lisa Kewley	Centre for Astrophysics - Harvard Smithsonian
Dr Sarah Leslie	Leiden Observatory, Leiden University
Dr Rebecca McElroy	University of Queensland
Dr Anne Medling	
Dr Sree Oh	Yonsei University
Professor Cristina Popescu	UCLAN
Dr Sarah Sweet	University of Queensland
Associate Professor Kim-Vy Tran	Harvard-Smithsonian Centre for Astrophysics
Ms Dian (Pipit) Triani	Centre for Astrophysics
Miss Haobing Wang	University of Sydney
Charlotte Welker	City University of New York, USA
Dr Ivy Wong	CSIRO
Dr Giulia Santucci	University of Western Australia
Associate Professor Elena D'Onghia	Other
Dr Vanessa Moss	CSIRO
Other Melissa Ness	Columbia University
Dr Maria Lugaro	Monash University
Dr Madeline Marshall	National Research Council of Canada
Associate Professor Patricia Tissera	Pontificia Universidad Catolica de Chile
Dr Maria Bergemann	Max Planck Institute for Astronomy, Niels Bohr International Academy
Dr Karin Lind	Department of Astronomy, Stockholm University
Associate Professor Charlotte Mason	Cosmic DAWN Center Niels Bohr Institute University of Copenhagen
Professor Alice Quillen	University of Rochester
Dr Adam Batten	Swinburne University of Technology
Dr Andrew Battisti	The Australian National University
Professor Michael Stanley Bessell	The Australian National University
Dr Alex Cameron	Oxford University
Professor Duncan Forbes	Swinburne University of Technology
Professor Alexander Heger	Monash University
Dr Colin Jacobs	Swinburne University of Technology
Professor John Lattanzio	Monash University
Professor Sergio Leon-Saval	University of Sydney
Dr Govind Nandakumar	Lund University, Sweden
Dr Stas Shabala	University of Tasmania
Dr Thorsten Tepper Garcia	University of Sydney
Ming Zhu	NAOC
Dr Phil Edwards	CSIRO
Professor Springel Volker	HITS
Dr Simon Campbell	Monash University
Dr Themiya Nanayakkara	Swinburne University of Technology
Dr Alexander Wallace	Monash University
Dr Jonah Gannon	Swinburne University of Technology
Dr Steven Janssens	Swinburne University of Technology
Dr Robert Adriel Mostoghiu Paun	Swinburne University of Technology
Dr Joel Pfeffer	Swinburne University of Technology
Dr Antoine Marchal	The Australian National University
Associate Professor Christian Wolf	The Australian National University
Dr Giacomo Cordoni	The Australian National University
Dr Carolyn Doherty	Monash University
Dr Suk Yee Yong	CSIRO
Dr Elizabeth Iles	University of Sydney

ASTRO 3D PHD, MASTERS AND HONOURS STUDENTS

ASTRO 3D has a significant number of PhD students completing their doctorates under the supervision of an ASTRO 3D researcher. We also have undergraduate Masters and Honours students doing ASTRO 3D-related research.

Ms Stephanie Bernard	University of Melbourne
Miss Giulia Cinquegrana	Monash University
Ms Hasti Nateghi	Swinburne University of Technology
Ms Xi Wang	The Australian National University
Miss Kirsten Banks	University of NSW
Ms Caro Derkenne	Macquarie University
Miss Jae Yeon Mun	The Australian National University
Miss Yifan Mai	University of Sydney
Ms Luisa Buzzo	Swinburne University of Technology
Miss Madeleine McKenzie	The Australian National University
Ms Sonja Panjkov	University of Melbourne
Ms Katy Proctor	University of Western Australia
Miss Manasvee Saraf	University of Western Australia
Miss Madeline Howell	Monash University
Miss Zara Osborn	Monash University
Ms Allison Morton	Swinburne University of Technology
Ms Hillary Davis	University of Sydney
Miss Peixin Zhu	The Australian National University
Ms Qianhui Chen	The Australian National University
Dr Sinem Ozbilgen	University of Melbourne
Miss Alma Sebastian	Swinburne University of Technology
Miss Aishwarya Selvaraj	Curtin University
Miss Sujeeporn Tuntipong	University of Sydney
Miss Hye-Jin Park	The Australian National University
Ms Lydia Haacke	Swinburne University of Technology
Mr Aldo Mura Guzman	The Australian National University
Mr Pablo Corcho-Caballero	Macquarie University
Mr Aman Chokshi	University of Melbourne
Mr Amir Ebadati Bazkiaei	Macquarie University
Mr Aaron Myszka	Swinburne University of Technology
Mr Tomas Rutherford	University of Sydney
Mr Simon Weng	CSIRO
Mr Matthew Wilkinson	University of Western Australia
Mr Hongwei Xi	CAS - Chinese Academy of Science
Mr Jaiden Cook	Curtin University
Mr Balu Sreedhar	University of Melbourne
Mr Daniel McPherson	Swinburne University of Technology
Mr Miftahul Hilmi	University of Melbourne
Mr Andrei Ristea	University of Western Australia
Mr Songlin Li	The Australian National University
Mr Adam Ussing	Swinburne University of Technology
Mr Emanuele Maria Ventura	University of Melbourne
Mr Rory Elliott	Swinburne University of Technology
Mr Ravi Jaiswar	Curtin University
Mr Lachlan Marnoch	Macquarie University
Mr Giovanni Ferrami	University of Melbourne
Mr Aadarsh Pathak	University of Melbourne
Mr Finn Pal	University of NSW
Mr Yoshiya Mori	Monash University
Mr Mark Suhr	Swinburne University of Technology
Mr Ryan Bagge	University of NSW
Mr Peter Watson	Oxford University
Mr Aman Khalid	University of NSW
Mr Oguzhan Cakir	Macquarie University
Mr Nicolò Dalmasso	University of Melbourne
Mr Maksym Mohorian	Macquarie University
Mr Evans Owusu	University of NSW
Mr Chien-Chang Ho	The Australian National University
Mr Jordan D'Silva	University of Western Australia
Mr Ajay Dev	University of Western Australia
Mr Angel Chandro Gomez	University of Western Australia
Mr Matthew Frosst	University of Western Australia
Mr Kris Walker	University of Western Australia
Mr Matthew Thomas	University of Melbourne
Mr Junhao Li	University of Western Australia
Mr Andrew Sullivan	University of Western Australia
Mr Nikolaos Maragkakis	University of Western Australia
Mr Benjamin Lowe	The Australian National University
Mr Isaac Kanowski	The Australian National University
Mr Tianmu Gao	The Australian National University

PhD Students

Mr Tamal Mukherjee	Macquarie University
Mr Pradosh Barun Das	Macquarie University
Miss Monserrat Martinez	Swinburne University of Technology
Miss Gabriella Quattropani	Macquarie University
Miss Emily Kerrison	University of Sydney
Miss Jaimie-rose Sheil	Monash University
Miss Antonia Fernandez Figueroa	Swinburne University of Technology
Ms Amy Miller	Macquarie University
Ms Alice Desmons	University of NSW
Miss Meghna Mukesh Menon	Macquarie University
Ms Kateryna Andrych	Macquarie University
Miss Sabrina Berger	University of Melbourne
Ms Jianling Tang	The Australian National University
Miss Magdalena Hamel Bravo	Swinburne University of Technology
Miss Lucia Paz Garate Núñez	University of Western Australia
Ms Seona Lee	University of Western Australia
Miss Louisa Canepa	University of NSW
Miss Zahra Aliakbar Zadeh	University of NSW
Miss Tamsyn O'Beirne	Swinburne University of Technology
Miss Nabomita Mukty	University of Sydney
Ms Maeva Berchon	Monash University

Masters students

Miss Tamsyn O'Beirne	University of Western Australia
Mr Adithya Gudalur Balasubramaniam	Macquarie University
Mr Benjamin Metha	University of Melbourne
Mr Nithin Babu	University of Melbourne
Mr Anilkumar Mailvaganam	Macquarie University
Mr Jahang Prathap Puthan Kallayi	Macquarie University
Ms Prina Bhugwan	University of Melbourne

Honours students

Miss Sophia Ridolfo	The Australian National University
Miss Stephanie Rowlands	Swinburne University of Technology
Mr Rongjun Huang	The Australian National University
Mr Eric Muller	The Australian National University
Miss YI Xie	The Australian National University
Ms Luka Mijnarends	The Australian National University

ASTRO 3D ALUMNI 2023

are former members of any category, who have moved onto a position outside of ASTRO 3D and who are not Affiliates or Stakeholders.

Dr Lilian Garratt-Smithson	University of Western Australia
Dr Keven Ren	University of Melbourne
Dr Alfred Tiley	University of Western Australia
Professor Andrew Hopkins	Other
Dr Steven Murray	Curtin University
Dr Marianne Girard	Swinburne University of Technology
Dr Cristina Martinez-Lombilla	University of NSW
Dr Adam Stevens	University of Western Australia
Dr Sanjib Sharma	University of Sydney
Dr David Yong	The Australian National University
Ms Melissa Van Dam	University of Western Australia
Miss Michelle Ding	University of NSW
Miss Jing Li	The Australian National University
Miss Cassidy Mihalenko	University of Melbourne
Miss Jemma Pilossof	University of Melbourne
Miss Jocelyn Ware	The Australian National University
Miss Katherine Meletiou	Monash University
Dr James Kariuki Chege	Curtin University
Dr Ruby Wright	University of Western Australia
Ms Jennifer Alyce Hardwick	University of Western Australia
Miss Jinying Lin	The Australian National University
Miss Di Wang	University of Sydney
Ms Stephanie Monty	The Australian National University
Dr Grace Lawrence	University College London
Dr Liyualem Ambachew Tilahun	Swinburne University of Technology
Mr Esteban Jiménez	University of Western Australia
Dr Zixian Wang	University of Sydney
Dr Tristan Reynolds	University of Western Australia
Mr Aman Chopra	The Australian National University
Dr Alex Kemp	Monash University
Mr Arvind Hughes	Macquarie University
Mr Wei Shen Oh	The Australian National University
Mr Zefeng Li	The Australian National University
Mr Juan Espejo	Swinburne University of Technology
Mr Yifei Jin	Harvard-Smithsonian Centre for Astrophysics
Mr Tanner Wilson	Monash University
Mr Joshua Joseph D'Agostino	The Australian National University
Dr Yisheng Qiu	University of Melbourne
Ms Pia Jakobus	Monash University
Ms Jessica Thorne	University of Western Australia
Mr Ji-Jia Tang	The Australian National University
Dr Jennifer Sobeck	Caltech - California Institute of Technology
Dr Jonghwan Rhee	University of Western Australia
Dr Sambit Roychowdhury	University of Western Australia

ADVISORY BOARD CHAIR REPORT

This year has seen extraordinary achievements by members of the ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D). In particular, I would like to congratulate Professor Emma Ryan-Weber who has been inspirational as the new Director of the Centre since April 2023. Heartfelt thanks to Professor Stuart Wyithe who stepped down as Director to take on his new role as Director of the Research School of Astronomy and Astrophysics at ANU. I would also like to recognise the outstanding contribution of Ingrid McCarthy, the Chief Operating Officer of the Centre, who will leave this position after more than six years with ASTRO 3D.

The impact and influence of the Centre continues to be exceptional. There have been over 1500 papers published to date, advancing knowledge for so many major big questions in astronomy, including the origin of matter, the elements and the ionised universe, cosmic structure and galaxies and their environments. There is increasing cross-collaboration across projects with plans for capture of the data products from major surveys such as GALAH, Hector and MAGPI. Training on access and use of the data is a priority. It is excellent that activities throughout the year have included successful conferences on galaxies and outflows, substantial time allocation on a range of national and international telescopes, and high performance computing access. A Science meeting in June and a successful Retreat in November at Tangalooma on Moreton Island (Mulgumpin) in Queensland have highlighted achievements. At the Retreat, the Advisory Board met with cohorts of students, professional staff, ECRs, MCRs and senior astronomers, as well as the Executive. There was real enthusiasm displayed throughout the event and much dedication and effort to maximise the impact and outputs of the Centre.

The rich legacy of the Centre will be the science discoveries, the tools and technologies developed and most importantly, the members of ASTRO 3D over its lifetime. You should be proud of the culture that has been nurtured, the leadership and inclusive collegiality that has been fostered, the focus on diversity and education, as well as your outstanding achievements.

Advisory Board Chair Emeritus Professor Anne Green (centre) and Board member Dr Bobby Cerini (left of centre) judge an Education and Outreach activity at the ASTRO 3D Annual Retreat. The activity required teams to explain their research via the medium of playdough.

EMERITUS PROFESSOR ANNE GREEN AC

Anne Green is Emeritus Professor of Astrophysics at the Sydney Institute for Astronomy in the School of Physics at the University of Sydney. Anne's research focussed on deep radio images of the Milky Way Galaxy, in particular the contribution to its structure and evolution by supernova remnants and astrophysical masers. She was the Director of the Molonglo Observatory for more than a decade and was appointed the first female Head of Physics at the University of Sydney in 2007. She was President of the ASA from 2003 to 2005 and was named a Companion (AC) in the Order of Australia in 2022 for eminent service to science, particularly physics and astrophysics, as an educator and researcher, as a mentor to colleagues and students and a role model to women.

The Anne Green Prize is awarded annually by the Astronomical Society of Australia for a significant advance or accomplishment by a mid-career scientist. She is very committed to mentoring the next generation of scientists.

Main: ASTRO 3D students at the ASTRO 3D Annual Retreat. Inset left and centre: Student workshop (organised and run by students) during the ASTRO 3D Science Meeting in May. Right Inset: Student workshop at the Annual Retreat

STUDENT COMMITTEE REPORT

The student committee has enjoyed another successful year of student activities, where we had our annual student workshop preceding the ASTRO 3D Science Meeting in May. Building on last year's feedback from students, we held a 1.5-day workshop addressing topics such as science communication, teaching astronomy in classroom settings, and machine learning applications. We also held a panel discussion on leadership, inviting women-identifying astronomers to speak about their leadership experiences. There were also opportunities for students to interact with one another in social settings, which included an escape room session along with a workshop dinner. Most of the attendees (40 in total) were in-person and the workshop was overall very well-received. At the annual retreat held in November, we had a workshop hosted by Cruxes Innovation on post-PhD career options outside of academia as well.

Aside from student workshops, the committee has also implemented some changes to ensure that students, especially those new to ASTRO 3D, are kept in the loop with the relevant news. We began sending out "welcome package" emails to new students, explaining the mission of ASTRO 3D, introducing the student committee, sharing key contacts to reach out to for node-based concerns, etc. We have also worked with Delese Brewster on an Expression of Interest form to better advertise outreach opportunities with ASTRO 3D for students.

The student committee has welcomed 3 new members this year - Giovanni Ferrami (Melbourne), Jordan D'Silva (UWA), and Aishwarya Selveraj (Curtin). We sincerely thank the outgoing members - Balu Sreedhar, Jennifer Hardwick, Jaiden Cook, and Yifan Mai for their service over the years. With Jennifer's departure, the committee has re-elected their chair and secretary as Marcie Mun (ANU) and Caro Derkenne (Macquarie), respectively. We'd like to thank all student committee members for their hard work this year, especially concerning the student workshop. We also could not have done this without the support of the Executive Management Committee, along with the continued engagement and enthusiasm of the student community. With the Centre going into its last year, we plan to hold a final student workshop in conjunction with the ASTRO 3D legacy meeting in June 2024. The committee will continue to meet monthly to discuss issues concerning students and to ensure students feel supported throughout their degrees as ASTRO 3D comes to an end.

Chair: Marcie Mun (ANU)

Committee: Caro Derkenne (Macquarie), Antonia Fernandez (Swinburne), Ryan Bagge (UNSW), Zara Osborn (Monash), Giovanni Ferrami (Melbourne), Jordan D'Silva (UWA), Aishwarya Selvaraj (Curtin)

JUNIOR ECR COMMITTEE REPORT

The Junior ECR Committee started the year by sending a survey to the ASTRO 3D postdocs in order to check on their well-being and identify their priorities. We received 20 responses. Based on this annual pool, 95% of ASTRO 3D junior ECRs felt supported by their institutions, with 75% choosing that ASTRO 3D was doing very well specifically for supporting ECRs. In terms of priorities, the top three preferences identified by more than 60% of junior ECRs were: (1) job opportunities in/outside astronomy, (2) future of ECRs after the end of ASTRO 3D, and (3) work-life balance/maintaining a positive mental health.

Thus, the Junior ECR Committee decided to organise a workshop covering the top two priorities during the Annual ASTRO 3D Science Meeting. The workshop was held in-person by Cruxes with the title 'Helping ASTRO 3D Researchers Explore Post-Centre Career Options' and both junior and senior ECRs attended. It focused on introducing tools and frameworks that junior ECRs could use for their career within and outside academia. In particular, junior ECRs were exposed to non-academic career options, and the workshop gave the researchers the skills and confidence to think about possible alternative jobs. Most of the skills and confidence came from the fact that the event was quite interactive with ECRs exposing their possible fears and worries. The ECRs reflected on which of their skills can be transferred to other fields and which could be strategic channels of networking. Most ECRs found the workshop helpful.

Finally, to better get to know each other, the Junior ECR Committee organised a virtual Trivia event. We did round-the-table presentations and new postdocs were introduced.

The Junior ECR Committee ended the year by submitting an application for a Junior ECRs Writing Retreat focused on job applications. The application would be consider for the next year and has the goal of helping junior ECRs' carreer in transitioning outside ASTRO 3D but within academia, via creating a supporting and empowering environment for one last time.

Main: ASTRO 3D Postdoctoral Researcher Dr Stefania Barsanti is the Junior ECR Committee Chair. Photo: Cristy Roberts/ANU

SENIOR ECR COMMITTEE REPORT

In 2023, the ASTRO 3D Mid-Career Researcher Committee focused on the needs and aspirations of mid-career researchers by organising a workshop on "5R Leadership" with Dr. Blake McMillon based around the framework of Readying, Reflecting, Representing, Realising, Reinforcing.

This workshop provided a platform for exploring the concepts of Social Identity Mapping and the relevance of acknowledging one's identity in leadership roles. Through exercises and discussions, participants gained insights into how their unique identities can influence their approach to leadership. The feedback from the event highlighted its effectiveness in enhancing self-awareness among researchers, aligning with the committee's objective to support professional development. Looking ahead, the committee aims to build on this foundation by facilitating more opportunities for growth and collaboration among mid-career researchers at ASTRO 3D and continue to be the voice of mid-career researchers in the Executive Management Committee.

Main: Senior ECRs meet with Prof. Anne Green and Dr Bobbi Cerini at the ASTRO 3D Annual Retreat. Inset from left: 5R Workshop and networking during the Retreat.

THE EQUITY, DIVERSITY AND INCLUSION COMMITTEE REPORT

The ASTRO 3D EDI Committee embarked on an inspiring journey throughout 2023.

The monthly Zoom meetings, held on the second Wednesday, were not mere routine gatherings; they were the nexus of progress and dedication. In line with our mission, the committee continued to play its role in fostering an inclusive environment within ASTRO 3D. Thanks to our stellar members in 2023: Tayyaba Zafar (MQ; chair), Ingrid McCarthy (ANU; Deputy chair), Marie Partridge (USyd; Secretariat), Taissa Danilovich (Monash), Giulia Santucci (UWA), Boquan Chen (ANU), Sven Buder (ANU), Tanner Wilson (Monash), Katie Auchettl (Melb), Duane Hamacher (UMel), Krystal De Napoli (Swinburne), Glenn Kacprzak (Swinburne), Tamal Mukherjee (MQ), and Sadaf Aliakbarzadeh (UNSW), setting the stage for a year of transformative change.

2023 evolution

In 2023, the committee saw significant shifts, amplyfying our impact and reach:

- Tayyaba Zafar assumed the role of Chair, succeeding Vy Tran. Vy Tran has embarked on a new journey at Harvard and her leadership was instrumental in guiding the committee through various initiatives.
- The merger of the BLM committee into EDI welcomed new voices, with Krystal De Napoli and Duane Hamacher adding valuable perspectives.
- Two dynamic student members, Tamal Mukherjee and Sadaf Aliakbarzadeh, added the committee with fresh energy and insights.
- Glenn Kacprzak commendable service concluded, leading to the search for a new member from Swinburne.

Awards and achievements

In recognition of the EDI efforts, ASTRO 3D secured the Silver Pleiades 2023 Award at the ASA Annual Scientific Meeting (see page 24)

2023 was a fantastic year celebrating gender parity with the publication of Kewley, Wyithe, Tran, and McCarthy's article in *Nature Astronomy*, showcasing the achievement of 50% women personnel achieved over five years by implementing a suite of evidence-based recruitment and retention initiatives.

Reporting mechanism

The Committee reached a significant milestone with the establishment of an anonymous reporting form, providing a platform to report and address any issues and concers promptly. Visit here to access the form and contribute to a supportive environment.

Training initiatives

- The ASTRO 3D EDI Committee remains committed in promoting a diverse, inclusive, and respectful environment, continually working towards positive change within the community. In 2023, the EDI committee worked over months to conduct two major training sessions:

- An impactful Active Bystander training held virtually on 15th November 2023 aimed to empower individuals with the knowledge and tools to effectively intervene in situations involving inappropriate behavior.

As part of our ongoing efforts to promote an inclusive and diverse astronomy community, Neurodiversity training and a panel discussion was held at the ASTRO 3D Annual Retreat at Tangalooma on 29th November 2023. Special thanks to Caroline Foster, Duane Hamacher, and Ingrid McCarthy for their courage in contributing to a meaningful discussion as panelists. Further appreciation to Marie Partridge, Taissa Danilovich, Ingrid McCarthy, Tayyaba Zafar and Boquan Chen for their dedication in organising these transformative sessions.

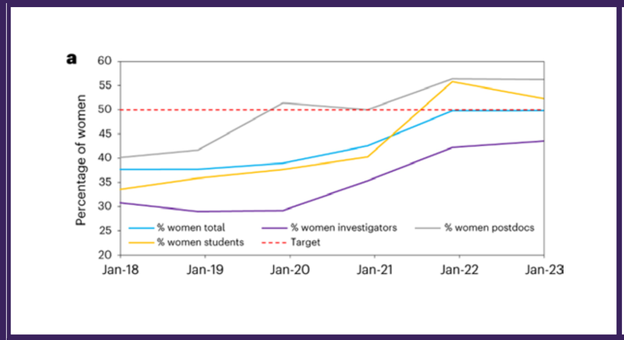
For both of these training sessions, additional material, including slides and feedback survey results were shared with the community via the ASTRO 3D Slack channel #astro3d-diversity.

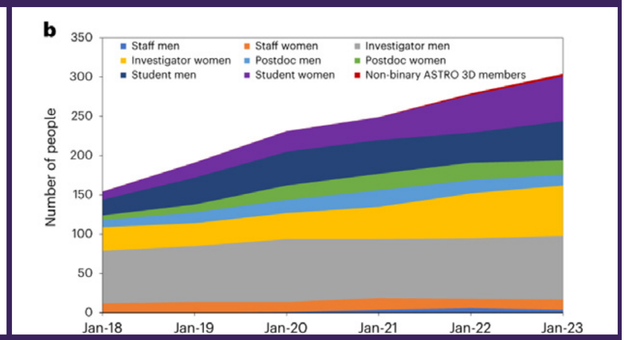
PhD hiring guidelines taskforce

The committee established a taskforce led by Sven Buder to delve into PhD hiring practices across nodes. The taskforce is on a mission to gather statistics and propose guidelines to ensure diversity balance.

As we reflect on 2023, the ASTRO 3D EDI Committee stands as a beacon of progress, unity, and inclusion. We are not only leading by example within ASTRO 3D but also setting a standard for other ARC CoEs. As we eagerly anticipate the vibrant growth ahead, we remain committed to sowing the seeds of positive change.

Image: (pictured from left) ASTRO 3D Director Emma Ryan-Weber, EDI Committee Chair Tayyaba Zafar and ASTRO 3D COO Ingrid McCarthy. Photo: Cristy Roberts/ANU.





Figures a, Percentage of women investigators, postdocs and students in ASTRO 3D over time. b, Number of women and men staff, students, postdocs and investigators in ASTRO 3D over time. Students include honours, masters and PhD students. Postdoctoral researchers include both postdoctoral fellows who work on independent research programmes and postdoctoral researchers employed for specific projects. Investigators are junior, mid-career and senior researchers affiliated with the centre. Staff refers to management, administration and education/outreach staff employed by the centre. From Nature Astronomy Paper.

GENDER PARITY

ASTRO 3D worked with Science in Public on an extensive media campaign to coincide with the publication of *Nature Astronomy* article ‘The achievement of gender parity in a large astrophysics research centre’, led by former ASTRO 3D Directors Lisa Kewley and Stuart Wyithe, as well as previous EDI chair Kim-Vy Tran and former Chief Operations Officer Ingrid McCarthy.

Director Emma Ryan-Weber starred on ABC TV News Breakfast with Nate Byrne. The TV interview was followed by two ABC radio broadcasts including the AM program and Radio National with Patricia Karvelas. National and international coverage continued during the day with articles in the Conversation, Science, and into the evening with ABC Perth’s Drive program.

The powerful messages in the story were the importance of women role models and transparent hiring. We emphasised how we have adopted a strategy based on evidence from the social sciences, and in 5 years had increased women’s membership from 38% to 50%. This result shows it can be done – and offers some tips other organisations can use. The change was brought about by a broad range of diversity initiatives across recruitment, retention, leadership and workplace culture.

We know gender parity improves research quality because it reduces the risk of bias and groupthink, which can affect the validity and reliability of scientific findings. Furthermore, diversity can lead to more innovative and creative solutions to scientific problems, as people from different backgrounds bring unique insights to the table.

It was wonderful day to celebrate our achievements with the wider community!

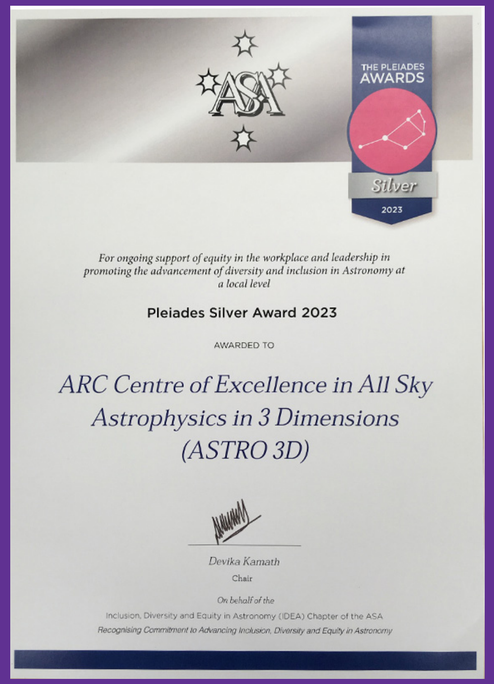
Main: ASTRO 3D Director Emma Ryan-Weber is interviewed on ABC News Breakfast with Nate Byrne. Inset right: Emma at the ABC RN Radio studio.

PLEIADES AWARD

ASTRO 3D was awarded a 2023 Silver Pleiades Award.

The Silver Pleiades recognises organisations with a sustained record of at least two years monitoring and improving the working environment. It also recognises leadership in promoting positive actions as examples of best practice to other organisations in the astronomy community.

‘The reflections and initiatives of ASTRO 3D in the areas of diversity and inclusion over the past several years are truly commendable. The IDEA Chapter Steering Committee appreciates ASTRO 3D's unwavering commitment to promoting equity in astronomy, and we highly value the strong emphasis placed on fostering an inclusive environment through the implemented efforts. Furthermore, we encourage your ongoing dedication to enhancing the visibility of pathways for reporting unacceptable behaviour among ASTRO 3D members.’



2024 SCIENCE ACTIVITY PLAN

ASKAP SURVEYS

DINGO

1. Process DINGO pilot phase 2 data
2. Process full DINGO survey data

FLASH

1. Investigate machine-learning options for classifying FLASH line finder output
2. Data release from first six months of full FLASH survey (DR2)
3. Updated data release from full FLASH survey (DR3)

WALLABY

1. Finalise preliminary WALLABY field selection
2. Internal release of first WALLABY survey data
3. Public release of WALLABY phase 2 pilot data
4. Organise annual WALLABY science meeting and/ or busy week

DATA INTENSIVE ASTRONOMY

1. Release interoperability of ASTRO 3D IFU survey archive data with Sky Mapper
2. Report on initial public 'ASTRO 3D simulation archive' release
3. Release enhanced interoperability of ASTRO 3D IFU survey archive data with CASDA and ESO
4. Release interoperability functions of ASTRO 3D simulation and observation archives

FIRST STARS

1. Use Gaia DR3 spectrophotometry to identify candidate extremely metal-poor stars in regions near the Galactic Disk. Followup with AAT/2dF/AAOmega with applications to ESO for X-Shooter and UVES time for detailed followup of best candidates. Science aim is to characterise population of EMP stars that have disk-like kinematics (low z-height, low eccentricity, significant circular velocity.
2. Calculate updated stellar nucleosynthesis models of metal-poor asymptotic giant branch (AGB) stars.
3. Calculate new stellar interior models of primordial and extremely metal-poor low and intermediate-mass stars
4. Use HPC to simulate convective-reactive (CR) events using 3D and 1D+ nuclear-hydrodynamics to investigate fast evolutionary phases in primordial stars in which the nuclear burning and turbulent mixing occur on similar timescales.
5. Mass-loss in metal-poor Galactic globular cluster stars. will use Kepler space telescope (K2) data to determine precise asteroseismic masses of stars in globular clusters. By targeting stars in various phases of evolution we can measure the integrated mass-loss of each evolutionary phase. This work will extend our knowledge of stellar mass-loss down to the low-metallicity regime.
6. Model the impact of binary stars on the yields of AGB stars, and investigate the implications for chemical evolution of galaxies. Similarly investigate the impact of novae on chemical evolution.
7. Chemical evolution of the heaviest elements and the rates of neutron star mergers in the Milky Way Galaxy
8. Generate revised yields for Pop III star supernovae based on new calculations involving a new nuclear reaction network.

GALAH

1. The Evolution of the Metallicity Gradient and the Age-Metallicity Relation
2. Classifying the Evolutionary State of Giants Using GALAH
3. Ages of TESS-HERMES-Gaia Stars
4. The Milky Way Rotation Curve Revisited
5. GALAH DR4

GALAXY EVOLUTION

1. CGM HI Kinematics
2. Analysis of HST data for CGM imaging
3. XQR30: Paper on XQR-30 metal absorber catalog (submitted)
4. XQR30: Paper on redshift evolution of CIV cosmic mass density (submitted)
5. Kinematics: Reduce & analyze current XSHOOTER data
6. Rosetta Stones paper (lensed dE at z~1)
7. SAMI Zoom catalogue paper
8. Kinematics: Paper - Disk settling
9. Kinematics: Paper - Disk thickness
10. AGEL: Manage first paper using CNNs for WDM substructure
11. Discovery of a z~6 protocluster in MAGPI
12. Connection between LINER emission and radio core
13. Analyse Xshooter data for EoR analogs
14. Metallicity gradient paper for TYPHOON spirals (Grasha+)
15. TYPHOON HII region catalog (Grasha+)
16. Paper:Messenger Monte-Carlo MAPPINGS V (M^3) – A self-consistent three-dimensional photoionization code
17. PHANGS stellar track paper (Grasha+)

GENESIS SIMULATIONS

1. Direct ingestion of Genesis data by SAGE
2. Development of tools to incorporate Genesis data into TAO
3. Get feedback from the astronomy community about the datasets they produce/want.
4. Study coupling of jet feedback to ambient medium in galaxies, combining detailed PLUTO AMR simulations with results from GADGET cosmological simulations
5. Develop suite of controlled non-cosmological simulations, cosmological zoom counterparts, and small cosmological volumes
6. Apply WhereWolf to N-body merger trees, and use OrbWeaver to classify orbits and interaction histories.

MWA EOR SURVEY

1. Publish census of ionospheric conditions in EoR fields with MWA
2. Process EoR2 field data through independent pipeline to test systematics introduced by RTS
3. Process LoBES data for improved EoR foreground model
4. Hyperdrive – incorporate redundant calibration, spectral regularisation
5. Develop and implement data quality visualisation with DuG
6. Explore the effect of diffuse emission on EoR end-to-end pipeline
7. Apply new ionospheric corrections, and LoBES catalogue to deep integration of data

SAMI | HECTOR SURVEY

1. Paper on adding shocks to models, then applying to early science data from Hector (as well as SAMI data)
2. Paper on modelling diffuse interstellar gas with above models, applying to off-planar gas in Hector
3. Paper on the merger history of slow rotators combining SAMI and HSC data
4. Mass scaling relations of low-mass galaxies with Hector
5. Different radial anisotropy between star-forming and quiescent galaxies in the SAMI, MAGPI and LEGA-C surveys
6. The hyperplane of early-type galaxies: a sharper tool for cosmology?
7. Development of slmspin code to run in both spectral and kinematic mode
8. Development of spinspin to become containerised web application, running on Data 8. Central servers and producing synthetic datacubes of simulations from the EAGLE, Illustris TNG, Magneticum, and Horizon AGN simulations

Background image: A look back to the ESO Ultra HD Expedition's time at Paranal – the stars within their grasp. redit: ESO/B. Tafreshi (twanight.org)

2023 MEDIA RELEASE

TRACING 13 BILLION YEARS OF HISTORY BY THE LIGHT OF ANCIENT QUASARS

REBECCA DAVIES

POSTDOCTORAL RESEARCHER AT SWINBURNE INSTITUTE OF TECHNOLOGY

Clearest picture yet of how the universe has developed through time

Astrophysicists in Australia have gathered the most detailed picture yet of the state of the universe 13 billion years ago by measuring the carbon density in the gases surrounding ancient galaxies.

The study adds another piece to the puzzle of the history of the universe.

“We found that the fraction of carbon in warm gas increased rapidly about 13 billion years ago, which may be linked to large scale heating of gas associated with the phenomenon known as the ‘Epoch of Reionisation’,” says Dr Rebecca Davies ASTRO 3D Postdoctoral Research Associate and lead author of the paper describing the discovery.

The study shows the amount of warm carbon suddenly increased by a factor of five over a period of only 300 million years – the blink of an eye on astronomical timescales.

While previous studies have suggested a rise in warm carbon, much larger samples – the basis of the new study – were needed to provide statistics to accurately measure the rate of this growth.

“That's what we've done here. And so, I present two potential interpretations of this rapid evolution,” says Dr Davies.

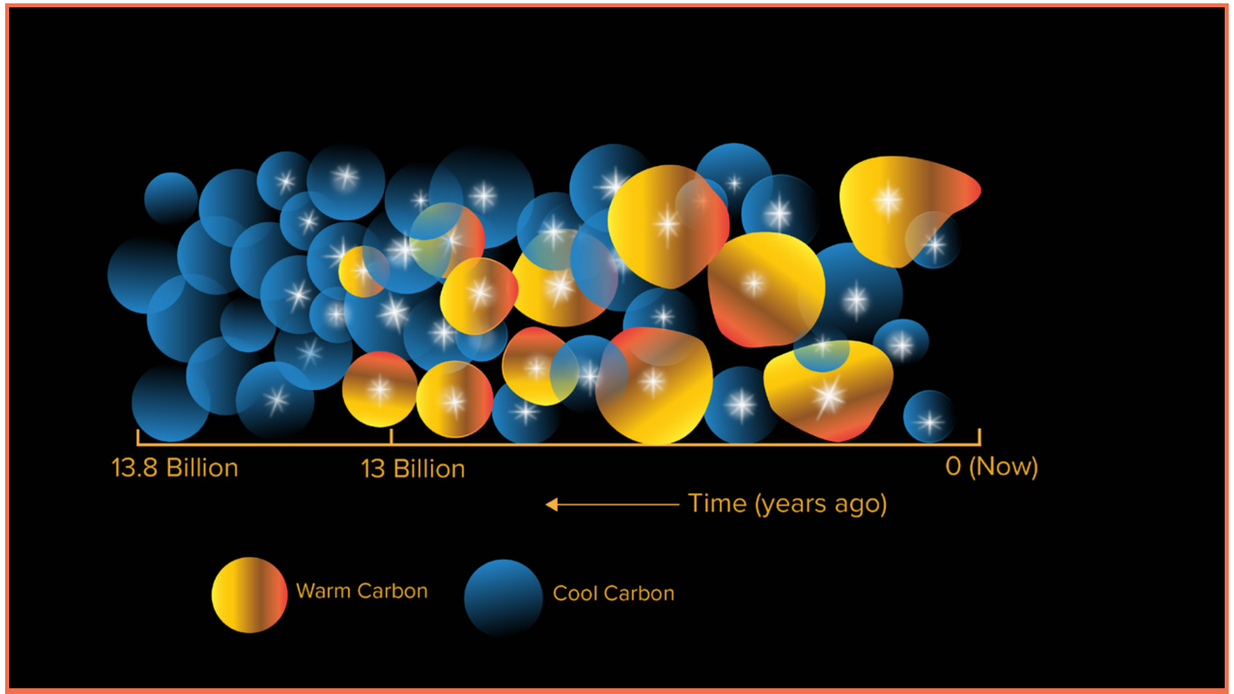
The first is that there is an initial increase in carbon around galaxies simply because there is more carbon in the universe.

“During the period when the first stars and galaxies are forming, a lot of heavy elements are forming because we never had carbon before we had stars,” Dr Davies says. “And so one possible reason for this rapid rise is just that we're seeing the products of the first generations of stars.”

However, the study also found evidence that the amount of cool carbon decreased over the same period. This suggests that there might be two different phases in the evolution of the carbon – a rapid rise while reionisation occurs followed by a flattening out.

The Epoch of Reionsation, which took place when the universe was “only” 1 billion years old, was when the lights came back on after the cosmic Dark Ages following the Big Bang.

Before this the universe was a dark, dense fog of gas but as the first massive stars formed their light began to shine through space and



Artist's impression of cool and warm carbon. Credit: Cristy Roberts ANU/ASTRO 3D

reionise the cosmos. This light may have led to rapid heating of the surrounding gas, causing the rise in warm carbon observed in this study.

Studies of reionisation are vital to understand when and how the first stars formed and began producing the elements that exist within us today, but measurements have been notoriously difficult.

“Our research was built on the largest catalogue of data constructed to date from 250 hours of observations on the Very Large Telescope (VLT) from the European Southern Observatory,” says Dr Davies.

“We observed bright quasars in the early universe and the quasars act as flashlights illuminating galaxies along the path from the quasars to the Earth.

As the quasar light passes through the galaxies in its 13-billion-year journey across the universe, some of the photons are absorbed, creating distinctive barcode-like patterns in the light which can be analysed to determine the chemical composition and temperature of gas in the galaxies.

This gives an historical picture of the development of the universe.

“These ‘barcodes’ are captured by detectors at the VLT’s X-Shooter spectrograph,” Dr Davies explains.

“This instrument splits the galaxy light into different wavelengths, like putting light through a prism, allowing us to read the barcodes and measure the properties of each galaxy.”

The study led by Dr Davies captured more barcodes of ancient galaxies than ever before. Previously there were around 12 quasars with high quality data whereas this paper uses 42.

“It's almost four times larger than any previous sample of distant quasars with high quality measurements,” she says. “And so, we're able to make measurements much more accurately than previous studies.”

This sample will not be significantly improved until 30m-class telescopes comes online towards the end of this decade.

Astronomers are using many different types of data to build a history of the universe.

“Our results are consistent with recent studies showing that the amount of neutral hydrogen in intergalactic space decreases rapidly around the same time,” says Dr Davies.

“This research also paves the way for future investigations with the Square Kilometre Array (SKA) which aims to directly detect emission from neutral hydrogen during this key phase of the universe's history.”

2023 MEDIA RELEASE

HEAT SPOTS REVEAL GROWTH RATE OF A GALAXY 12 BILLION YEARS AGO

Precise mapping of temperature variation gives clue to its evolution.

A team of astronomers led by ASTRO 3D has drawn a temperature map of the dust drifting within one of the oldest spiral galaxies of the Universe which provides new insights into how fast the galaxy is growing. Until now researchers have only been able to measure the temperature of most distant galaxies in broad terms, without showing how temperatures vary in individual areas.

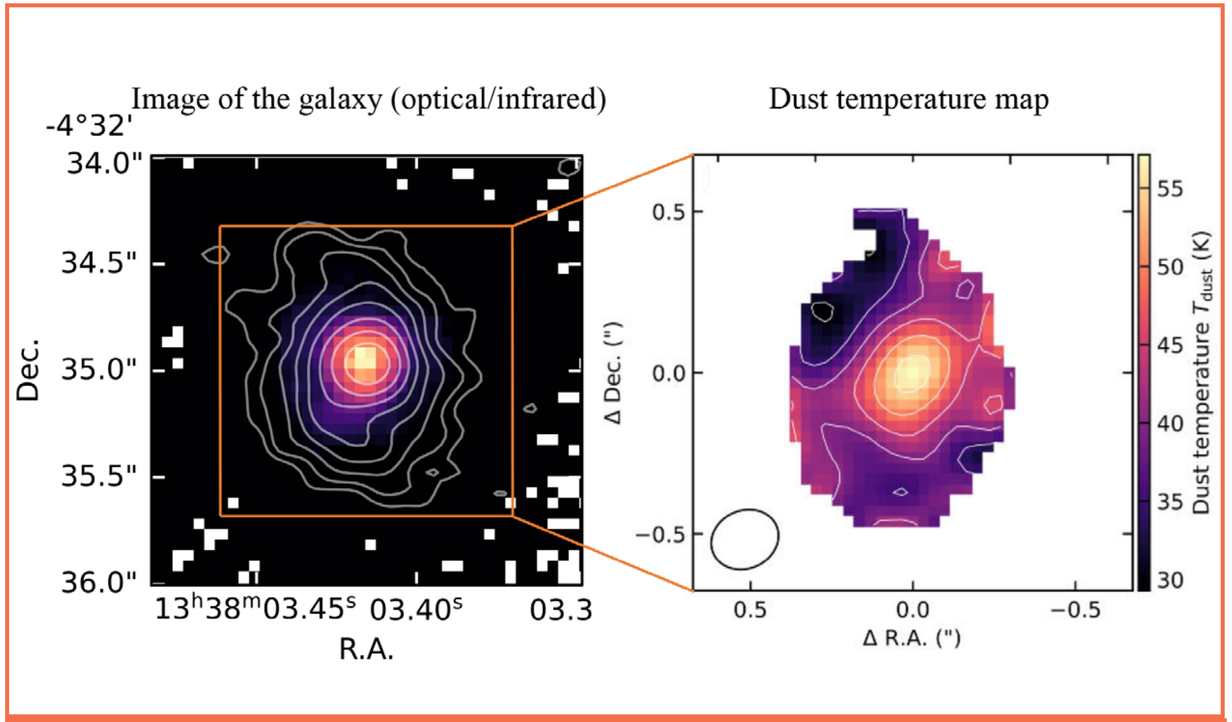
This research, described in a paper published today in *Monthly Notices of the Royal Astronomical Society* (*MNRAS*) shows unambiguous temperature variation within the distant galaxy indicating two distinct heat sources – a supermassive black hole at the centre of the galaxy, and the heat generated by newly-formed stars in the surrounding rotating disk.

“The temperature of a galaxy’s dust can vary greatly according to which region it is in,” says Dr Takafumi Tsukui of the Australian National University (ANU) in Canberra, lead author of the paper. “But most of the measurements of dust temperature for distant galaxies in the past have been for the galaxy as a whole, due to limited instrument resolution.

“We were able to measure the temperature by region to region that we could determine how much heat is coming from individual sources. Previously, such mapping has mostly been limited to nearby galaxies.”

The research reveals a clear distinction between warm dust in the central region – where the heat is derived from the galaxy’s supermassive black hole – and colder dust in the outer region, which is likely being heated by star formation.

Most galaxies have a supermassive black hole in the centre, which are thought to grow in mass with the galaxy. When the gas accretes to the black hole, it is heated up by collisions of the fast-moving particles in the vicinity of the black hole and sometimes shines brighter than the stellar body of the galaxy itself.



An optical image, left, of the galaxy captured by the Hubble Space Telescope with overlaid temperature contours as detected by ALMA. The image on the right shows the dust temperature map detailed in the study.

TAKAFUMI TSUKUI

POSTDOCTORAL RESEARCHER AT THE AUSTRALIAN NATIONAL UNIVERSITY

“The heating energy from the black hole reflects the amount of the gas being fed into it and so the black hole growth rate, while the heating energy from star formation reflects the number of stars newly forming in the galaxy – the galaxy growth rate,” Dr Tsukui says.

“This discovery provides a clearer picture of how galaxies and central massive black hole form and grow in the early Universe.”

The current research was made possible thanks to the Atacama Large Millimeter/submillimeter Array (ALMA) telescope operated by the European Southern Observatory (ESO) in Chile.

“This study demonstrates the detailed mapping ability of the ALMA telescope, operated by ESO,” ASTRO 3D Director Professor Emma Ryan-Weber said. “ALMA is the most powerful array for measuring millimetre and submillimetre radiation. It’s incredible that ALMA can look at a 12-billion year old galaxy and separate the image into two components – one of dust heated from the central super massive hole, and the other from the dust in underlying host galaxy.”

ALMA is a global collaboration and comprises 66 high-precision antennas, spread over distances of up to 16 kilometres making it the world’s largest ground-based astronomical project. It is designed to detect faint light from some of the coldest objects in the Universe which have wavelengths of around a millimetre, somewhere between infrared light and radio waves.

2023 MEDIA RELEASE

GAS-RICH BABY GALAXIES SET THE EARLY UNIVERSE ALIGHT

New images from the James Webb Space Telescope (JWST) have helped Australian astronomers unlock secrets of how infant galaxies started an explosion of star formation in the very early Universe.

Some early galaxies were abundant with a gas that glowed so bright it outshone emerging stars. In research published today, astronomers have now discovered just how prevalent these bright galaxies were some 12 billion years ago.

Images from the JWST have shown that almost 90% of the galaxies in the early universe had this glowing gas, producing so-called 'extreme emission line features'.

"The stars in these young galaxies were remarkable, producing just the right amount of radiation to excite the surrounding gas. This gas, in turn, shone even brighter than the stars themselves," says Dr Anshu Gupta from the ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D) and the Curtin University node of the International Centre for Radio Astronomy Research (ICRAR), the lead author of a paper describing the discovery.

"Until now, it was challenging to understand how these galaxies were able to accumulate so much gas. Our findings suggest that each of these galaxies had at least one close neighbouring galaxy. The interaction between these galaxies would cause gas to cool and trigger an intense episode of star formation, resulting in this extreme emission feature."

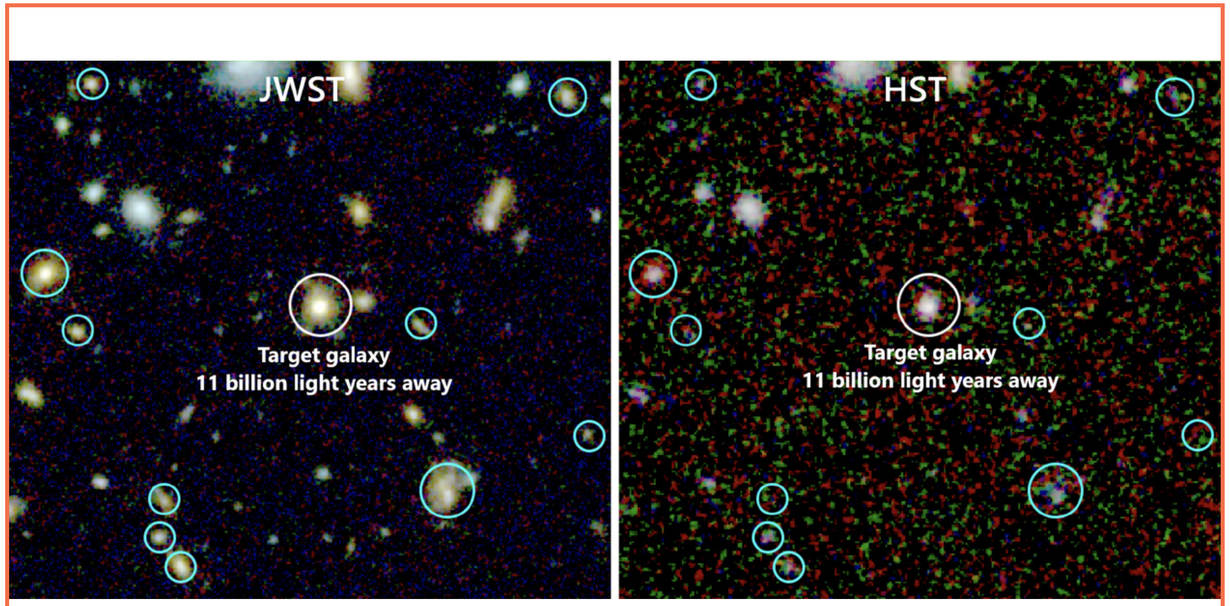
The discovery is a graphic example of the unparalleled clarity the JWST telescope provides in studying the early Universe.

"The data quality from the James Webb telescope is exceptional," says Dr Gupta. "It has the depth and resolution needed to see the neighbours and environment around early galaxies from when the Universe was only 2 billion years old. With this detail we were able to see a marked difference in the number of neighbours between galaxies with the extreme emission features and those without."

ANSHU GUPTA

ASTRO 3D, RESEARCH FELLOW AT CURTIN UNIVERSITY

Previously we struggled to get a clear picture of galaxies from around 2 billion years of the Universe's age. As many stars had yet to form, the task was made more difficult with many fewer galaxies to focus on.



Target galaxy seen by James Webb Space Telescope (left) and Hubble Space Telescope (right). The unprecedented resolution and clarity of JWST images allowed identification of neighbouring galaxies (cyan circles) that that Hubble could not even see.

"Prior to JWST, we could only really get a picture of really massive galaxies, most of which are in really dense clusters making them harder to study," Dr Gupta says. "With the technology available then, we couldn't observe 95% of the galaxies we used in this study. The James Webb telescope has revolutionised our work."

The discovery has proven previous assumptions, says fellow author Associate Director Tran, ASTRO 3D and the Center of Astrophysics, Harvard and Smithsonian. "We suspected that these extreme galaxies are signposts of intense interactions in the early universe, but only with the sharp eyes of JWST could we confirm our hunch," she says.

The research relied on data obtained as part of the JWST Advanced Deep Extragalactic Survey (JADES) survey, which is exploring the Universe of the earliest galaxies with deep infrared imaging and multi-object spectroscopy. It opens the way for further insights.

"What's really exciting about this piece is that we see emission line similarities between the very first galaxies to galaxies that formed more recently and are easier to measure. This means we now have more ways to answer questions about the early universe, a period that is technically very hard to study," says second author, Ravi Jaiswar, a PhD student at Curtin University/ICRAR and ASTRO 3D.

"This research is core to the work of our Galaxy Evolution Program. By understanding what early galaxies look like, we can build on answering questions on the origin of the elements that make up our everything in our everyday life here on Earth." says Professor Emma Ryan-Weber, Director of ASTRO 3D.

2023 MEDIA RELEASE

GENDER PARITY IN ASTRONOMY IN JUST 5 YEARS

Around the world, research agencies are struggling to achieve gender parity.

A paper published in *Nature Astronomy* today reports how a national Australian astronomy centre achieved equal numbers of women and men using science. “We used research in sociology and psychology to develop evidence-based strategies, and to create a supportive and positive culture in our Centre,” says Professor Lisa Kewley, the founding director of ASTRO 3D, the Australian Research Council Centre for All Sky Astrophysics in 3 Dimensions, and the lead author on the paper. Professor Kewley now leads the Center for Astrophysics, Harvard & Smithsonian. “Our success offers a model to other organisations, especially in the physical sciences where participation rates for women continue to be well behind the biological sciences, and where gender equality has remained stubbornly low,” says Professor Emma Ryan-Weber, the current Director of ASTRO 3D.

“Astronomy is a gateway science,” says Professor Ryan-Weber. “Students are fascinated by the question of what’s out there in space and how the elements that fused inside stars end up being the oxygen we breathe. I am proud that our centre is providing a diverse range of role models for the next generation – encouraging them to take up maths and physics, which opens up career opportunities not just in astronomy but across the physical sciences and a range of technical industries, such as data science.”

“Astronomy is regarded as leading in gender equity in the physical sciences. But when we established ASTRO 3D in 2017, I looked at the numbers and realised that on current trends it would take more than 60 years to reach gender parity,” says Professor Kewley. Across Australia, women make up 30 to 35% of PhD astronomy students, and less than 20% at the highest professorial level. “And women are more than three times more likely to leave the profession. Sixty-two per cent of women and 17% of men leave astronomy at the junior postdoctoral levels. We had to do better,” Professor Kewley says. Our program was implemented between December 2017 and January 2023. In that time, ASTRO 3D went from 38% women to 50%,” she says.

LISA KEWLEY

FOUNDING DIRECTOR OF ASTRO 3D, CURRENT DIRECTOR OF CENTER FOR ASTROPHYSICS HARVARD & SMITHSONIAN

The key steps included:

- setting diversity targets with regular monitoring of progress
- selecting a diverse set of team leaders
- in-person diversity training for all organisation members
- ensuring 50% women on postdoctoral selection committees
- ensuring 50% women on postdoctoral short-lists.

The ASTRO 3D team at the 2022 annual retreat. Credit: Cristy Roberts.

“Diverse leadership is crucial for improving the diversity within teams,” says Professor Stuart Wyithe, Director of the Research School for Astronomy & Astrophysics, The Australian National University. “Women-led teams recruited and retained more women postdoctoral researchers, attracted more women students, and worked with more women collaborators, while the converse was true for men-led teams,” he says.

“The ASTRO 3D program reached a tipping point when there were 40% women in the organisation as supervisors, mentors and role models for students. After that, student enrolments by women in the Centre accelerated. The gains were not made at the expense of men, as the membership grew over this period,” Professor Kewley says.

Recruiting women is one thing, but retaining them is just as important and ASTRO 3D introduced a range of policies to make sure their staff felt welcome and valued. These included a focus on leadership development, promotion of work-life balance, partner recruitment, as well as pathways for reporting misconduct.

In all categories, larger percentages of women were retained than men.

Among students, 55 to 58% women were retained compared with 37 to 48% men and a larger percentage of women postdoctoral researchers were retained in the Centre (67 to 70% women and 55 to 69% men).

“This suggests that the presence of women supervisors and role models is critical for attracting and retaining women.” Professor Ryan-Weber, who is also an astronomer at Swinburne University of Technology, says the paper clearly paves the way for other research centres to achieve similar results.

“Our researchers have made phenomenal discoveries in understanding how elements, stars, galaxies and the gas that surrounds them evolved from the early Universe to today. Their skills have translated to international success in academia and to solve real-world problems in industry.

“But the greatest legacy of ASTRO 3D may be as a role model for better diversity in research,” she says.

2023 MEDIA RELEASE

ASTRONOMERS DETECT SEISMIC RIPPLES IN ANCIENT GALACTIC DISK

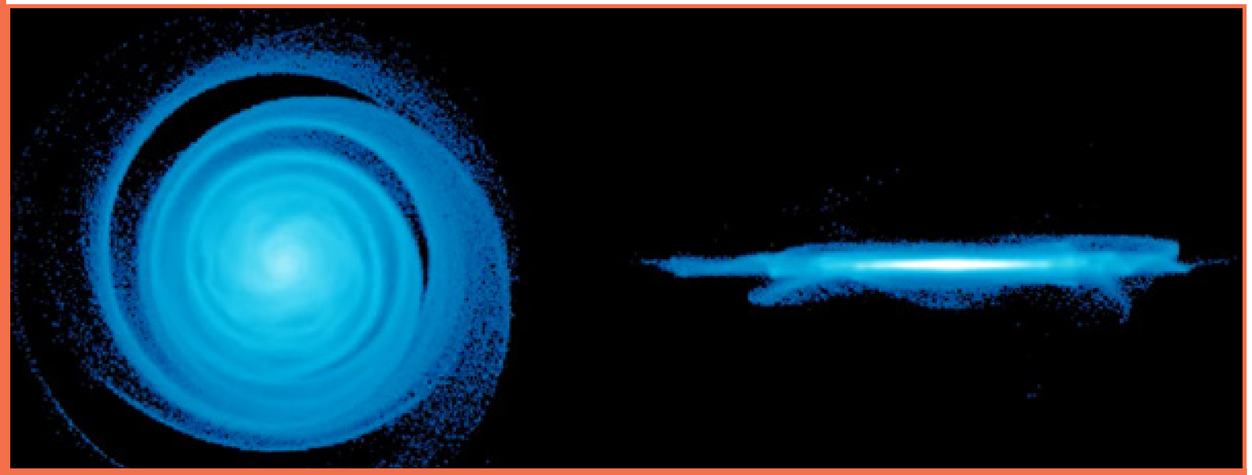


Image: Illustration of a galaxy disk being disturbed. Photo: Jonathan Bland-Hawthorn and Thorsten Tepper-Garcia/University of Sydney

TAKAFUMI TSUKUI

POSTDOCTORAL RESEARCHER AT THE AUSTRALIAN NATIONAL UNIVERSITY

Still from a simulation showing the formation of a spiral galaxy. Credit: Takaaki Takeda, Sorahiko Nukatani, Takayuki R. Saitoh, 4D2U Project, National Astronomical Observatory of Japan (NAOJ)

A new snapshot of an ancient, far-off galaxy could help scientists understand how it formed and the origins of our own Milky Way.

At more than 12 billion years old, BRI 1335-0417 is the oldest and furthest known spiral galaxy in the universe. Lead author Dr Takafumi Tsukui said a state-of-the-art telescope called ALMA allowed them to look at this ancient galaxy in much greater detail. “Specifically, we were interested in how gas was moving into and throughout the galaxy,” Dr Tsukui said. “Gas is a key ingredient for forming stars and can give us important clues about how a galaxy is actually fuelling its star formation.”

In this case, the researchers were able to not only capture the motion of the gas around BRI 1335-0417, but also reveal a seismic wave forming – a first in this type of early galaxy. The galaxy’s disk, a flattened mass of rotating stars, gas and dust, moves in a way not dissimilar to ripples spreading on a pond after a stone is thrown in.

This new data means we now know more about how the galaxy formed. “The vertically oscillating motion of the disk is due to an external source, either from new gas streaming into the galaxy or by coming into contact with other smaller galaxies,” Dr Tsukui said. “Both possibilities would bombard the galaxy with new fuel for star formation.

“Additionally, our study revealed a bar-like structure in the disk. Galactic bars can disrupt gas and transport it towards the galaxy’s centre. The bar discovered in BRI 1335-0417 is the most distant known structure of this kind. “Together, these results show the dynamic growth of a young galaxy.”

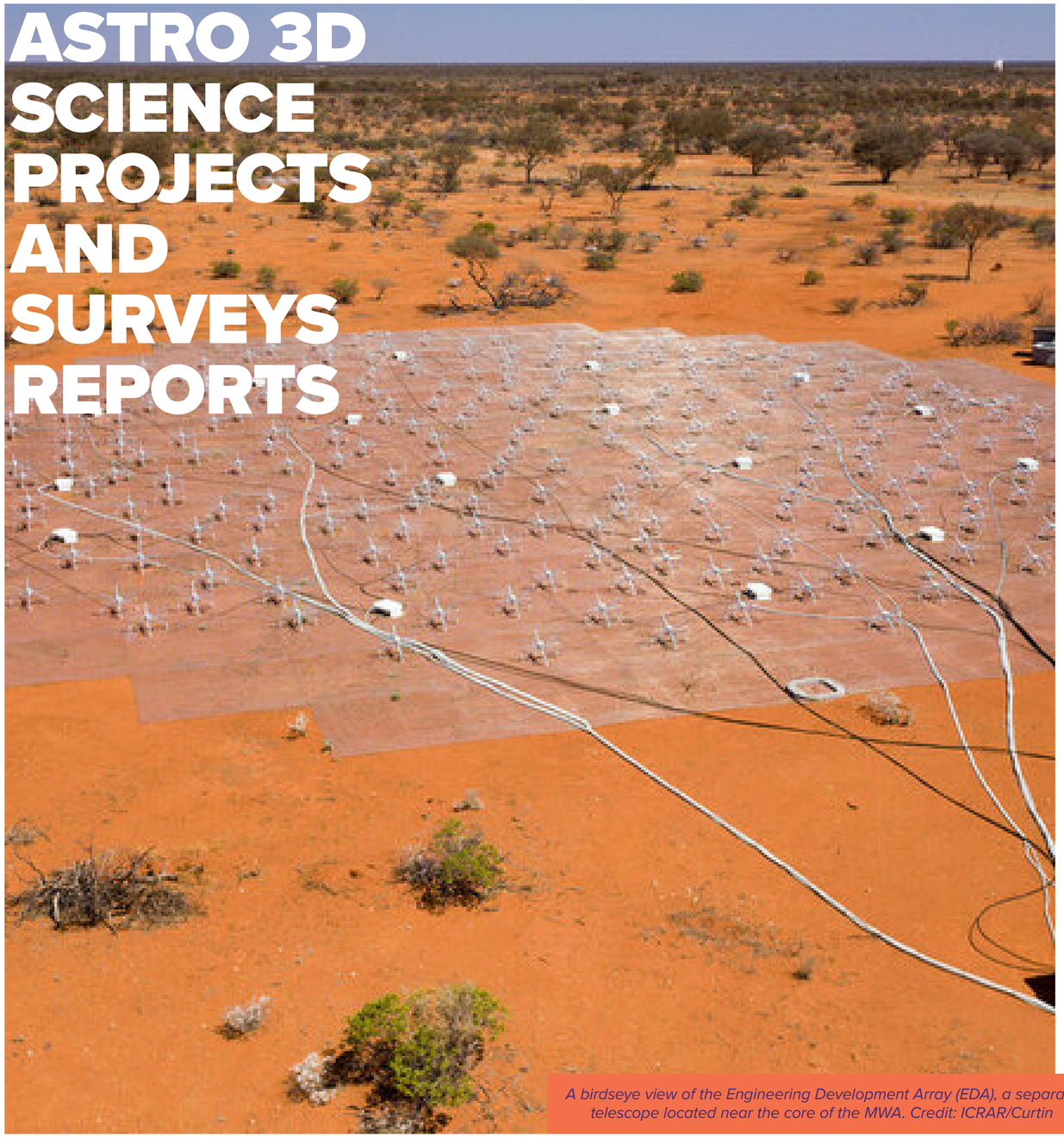
Because BRI 1335-0417 is so far away, its light takes longer to reach Earth. The images seen through a telescope in the present day are a throwback to the galaxy’s early days — when the Universe was just 10 per cent of its current age. “Early galaxies have been found to form stars at a much faster rate than modern galaxies. This is true for BRI 1335-0417, which, despite having a similar mass to our Milky Way, forms stars at rate a few hundred times faster,” co-author Associate Professor Emily Wisnioski said. “We wanted to understand how gas is supplied to keep up with this rapid rate of star formation. Spiral structures are rare in the early Universe, and exactly how they form also remains unknown. This study also gives us crucial information on the most likely scenarios. While it is impossible to observe the galaxy’s evolution directly, as our observations only give us a snapshot, computer simulations can help piece the story together.”

The study has been published in *Monthly Notices of the Royal Astronomical Society.*

The ALMA (Atacama Large Millimeter/submillimeter Array) observatory, part of the European Southern Observatory (ESO), is comprised of 66 antennas which observe a single galaxy in unison. The data from each antenna are combined to create a single image of the galaxy using a supercomputer. This observatory played a pivotal role in the study.

https://astro3d.org.au/astronomers-detect-seismic-ripples-in-ancient-galactic-disk/.https://doi.org/10.1093/mnras/stad3588

ASTRO 3D SCIENCE PROJECTS AND SURVEYS REPORTS



A birdseye view of the Engineering Development Array (EDA), a separate telescope located near the core of the MWA. Credit: ICRAR/Curtin

MURCHISON WIDEFIELD ARRAY | EPOCH OF REIONISATION (MWA EoR)

The Murchison Widefield Array (MWA) is an SKA precursor low-frequency radio telescope interferometer operating at Inyarrimanha Ilgari Bundara, CSIRO's Radio Astronomy Observatory. With observations commencing in 2013, the MWA Epoch of Reionisation (EoR) Collaboration has collected more than 2000 hours of data on three key observing fields in the southern sky, away from the Galactic Plane, with the ambition to detect signals from primordial hydrogen from the first billion years of the Universe. The temperature and distribution of the hydrogen gas maps the radiation and thermal environment of the Universe, and tracing the growth the first stars and galaxies.

The MWA EoR project is immensely challenging, with the exceptionally weak hydrogen signal embedded within the bright foreground sky of our own Milky Way Galaxy, and other radio galaxies in the sky. The ASTRO 3D efforts have centred around improving calibration of our data, having a more complete understanding of the full signal chain from the early Universe, through the telescope, to our data products, and the analysis of our data to hunt for the weak cosmic signal.

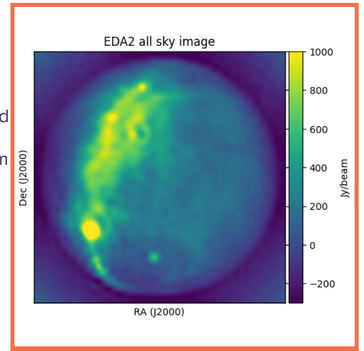
2023 Project Highlights

The MWA EoR project team made significant advances in 2023 toward the goal of detecting the cosmological 21cm signal from the Early Universe, completing a number of project milestones.

Dr Chris Jordan has completed the Hyperdrive MWA calibration software. This is now being used internationally in the MWA EoR collaboration, and also by other MWA science groups. Hyperdrive is a modular, documented, tested and efficient data processing pipeline that was one of the major ASTRO 3D milestones.

Dr Jack Line has made major advances with his WODEN end-to-end MWA EoR simulation software, producing realistic datasets, and demonstrating minimal signal loss from sky to output science results. This software can now be used to test different systematic errors in the data and how they affect our results. As another major ASTRO 3D milestone project, WODEN presents the team the ability to understand the impact of data quality, and analysis choices, on the output science. Feeding into this work is that of PhD student Aman Chokshi, who has returned from his year in Antarctica to work on understanding how small errors in our understanding of the primary beam of tile of the telescope (how the telescope observes the field in the sky) can map into errors that obscure our view of the early Universe.

Dr Ridhima Nunhokee has been analysing large sets of MWA data for a data quality assessment project, working from the processing pipeline developed and operated by Dev Null. Dev's pipeline makes download and processing of the MWA EoR data seamless and efficient, allowing the team to rapidly apply new calibration and analysis techniques to the thousands of hours of MWA EoR data. This work will be leading to a new science result in 2024 where all the learnings are applied and we aim to get closer to detecting the cosmological signal.



All-sky simulation with the EDA2 instrument using the WODEN simulator tool. WODEN's ability to simulate accurate all-sky images allows the MWA EoR project to test its data analysis tools (credit: Dr Jack Line).

Jaiden Cook led a cross-project, cross-node paper detailing the skew spectrum of 21cm signal, as observed with a real telescope. Jaiden used Genesis boxes, combined with Meraxes, generated by Balu Sreedhar and Brad Greig, to look at the evolution of the power and skew spectra of 21cm signal from the early Universe, and understand what data from the MWA would look like with different models for the astrophysics of the early Universe.

PhD student Aishwarya Selvaraj and Randall Wayth achieved 'first light' fringes on the CRAM external instrument, connected to the MWA as a larger tile which observes the sky differently to the rest of telescope, and has the ability to separate troublesome foreground signal from the cosmological 21cm signal for the EoR experiment. CRAM is now included in the MWA signal chain and routinely produces data with the rest of the MWA.

Professor Cathryn Trott led work to analyse 410 hours of archival data from the Australia Telescope Compact Array (ATCA) to search for evidence of evolution in the primordial helium signal from 1 billion - 2 billion years after the Big Bang. In this period helium underwent its reionisation (much like hydrogen). This is the first attempt to measure the helium signal in the Universe using its hyperfine radio emission line.

Dr Chris Jordan led the 'Wizards of Oz 3D' team in the 3rd SKA Data Challenge, which focussed on power spectrum estimation in the presence of foregrounds and instrumental errors. Dr Ridhima Nunhokee, Dr Jack Line and PhD student Aishwarya Selvaraj worked on improving the sky model for data calibration and source subtraction, while Dr Chris Jordan, Mx Dev Null and Professor Cathryn Trott worked on data calibration and power spectrum estimation. The team scored well, coming in 7th place in a field of 20 international teams.

Personnel Highlights

Dr Nichole Barry was awarded a DECRA; Dr Chris Jordan completed his contract and moved into industry; Dev Null joined as an Associate to work in the team as a software engineer; former PhD student Mike Kriele graduated his PhD; Dr Nichole Barry was co-awarded the ASA Louise Webster Prize; PhD student Jaiden Cook submitted his PhD.

Cross-Project Collaborations

Jaiden Cook (MWA EoR) and Balu Sreedhar (Genesis) led a paper to take augmented Meraxes boxes, derived from Genesis boxes, and simulate them with WODEN to produce realistic mock MWA data. Jaiden then computed second and third-order statistics to understand how they were observed through the MWA instrument, and what information could be extracted from them.

SAMI | HECTOR SURVEYS

SAMI and Hector are two integral field spectrographs that allows the measurement of a huge range of galaxy properties that are impossible to obtain from single fibre surveys and allows direct tests of the latest galaxy formation simulations. Observables include gas and stellar internal and bulk kinematics, the spatial distribution of star formation, stellar metal content and age gradients, gas oxygen abundance distributions, resolved ionisation diagnostics and many others.

The SAMI Galaxy Survey (https://s ami-survey.org/) of over 3000 galaxies is the first integral field sample that is sufficiently large to disentangle the competing roles of galaxy mass and environment. As a result, we can address the following three key questions:

1. What is the physical role of environment in galaxy evolution?
2. What is the interplay between gas flows and galaxy evolution?
3. How are mass and angular momentum built up in galaxies?

The Hector Galaxy Survey is building on SAMI using a new instrument with higher spectral resolution, a wider field of view, and the ability to target more galaxies at once. Hector is carrying out a survey of up to 15000 galaxies.

Hector Highlights 2023

The Hector Galaxy Survey (led by CI Prof. Julia Bryant, Sydney University) began in earnest in 2023 with over 1500 galaxies observed in the year. These galaxies come from a broad range of environments from isolated galaxies through to the densest clusters. The data is now being used to look at the impact of both local and global environments on the properties of the galaxies.

The SAMI data reduction pipeline has been adapted and improved for Hector, and new multi-component emission and continuum fitting code is being written to produce spectral line fitting for all galaxies. The first internal data release has been produced for the Hector team and the spectral line products will be available at the start of 2024, ready for the early science papers on galaxies that are (a) Milky Way analogues, (b) have winds and outflows, and (c) have transformations driven by the environments they live in.

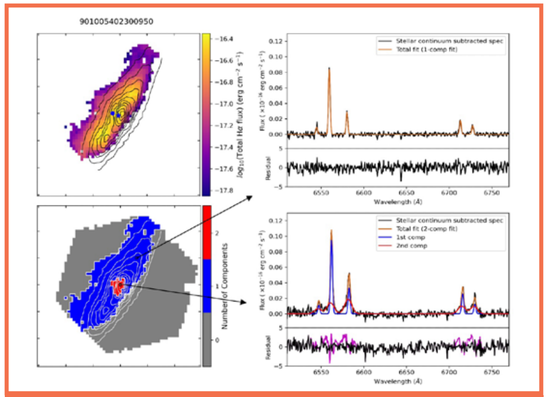


Figure 1: A ram pressure stripped candidate galaxy in Abell 3667 identified by Hectors new multiple Gaussian component emission line fitting code developed by student Gabriella Quattropani (Macquarie). Top left: The asymmetric distribution of Ha ionised gas (colours) extends beyond the stellar disk (black contours) towards the top left of the image, indicating the gas is being swept off the galaxy in that direction by the interaction with the cluster medium. Bottom left: A map of how many gaussian component were required to fit the emission line in each of the spectra as chosen by Bayesian Information Criterion (BIC). Top right: Typical one component fit with narrow (σ ~ 35 km/s), star-forming like (log([NII]/Ha) ~ −0.47) emission lines. Bottom right: A typical two component fit where the second component indicates AGN-like emission with broad (σ ~190 km/s) lines and high log([NII]/Ha) ratio (~1.25). Conversely, the first component has star-forming like emission with lower log([NII]/Ha) ratio (~ −0.44). Therefore the new multi-component fitting has been effective in identifying the signature of ram pressure stripping in the offset gas as well as separating AGN emission in the galaxy centre and surrounding star formation in the gas disk.

SAMI Highlights

In 2023 SAMI continued to exploit the full same data set to address a range of science questions. The team also expanded links to other projects, publishing several combined analyses. Below are some of the highlights of the year.

ASTRO 3D CI Barbara Catinella (UWA) published the first paper connecting SAMI data with atomic hydrogen (the SAMI-HI project), measurement at radio wavelengths. This work showed that there are offsets between the rotational velocities measured with ionized (SAMI) and atomic (HI) gas. PhD student Adam Watts (UWA) used the SAMI-HI sample to investigate kinematic asymmetry, finding that there is little correlation between asymmetry in ionized and atomic gas.

Caroline Foster (UNSW) showed that the dynamics of gas and stars in SAMI galaxies are coupled, particularly for young stellar populations. Further kinematic analysis, using complex dynamical modelling was published by Giulia Santucci (UWA), finding that stellar orbits in galaxies depend on both mass and environment.

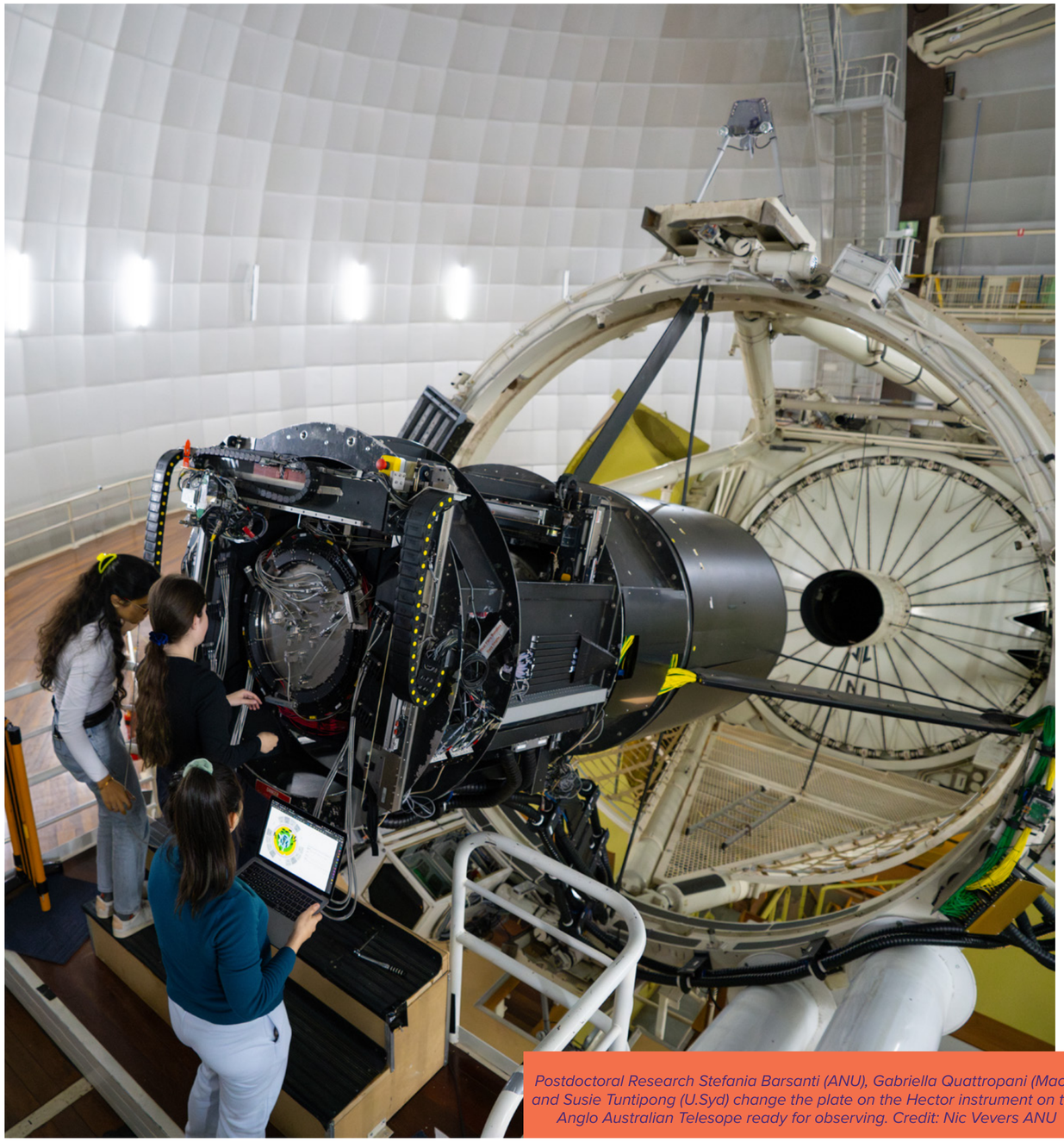
PhD student Di Wang (Sydney) collaborated with Claudia Lagos (UWA) in the Genesis team to show how the concentration of star formation is related to environment in simulated galaxies.

Connecting SAMI, MAGPI and the ESO LEGA-C project, Francesco D'Eugenio (Cambridge) published two papers focused on the evolution of higher-order stellar kinematics across cosmic time. His results suggest that both star formation and merging is connected to galaxy dynamical structure.

Further exploring galaxy dynamics, Stefania Barsanti (ANU) found that nuclear activity plays a role in the spin alignment of galaxies with large-scale structure.

Personnel Highlights

Congratulations PhD student Di Wang who completed her PhD in 2023. PDRA Sree Oh, took a new position at Yonsei, in Korea, where she will continue to be a key player in the Hector Survey. CI Professor Matthew Colless (ANU) was awarded Officer of the Order of Australia for '*distinguished service to scientific research, particularly to astronomy and astrophysics, and to professional societies*'. The team had various visitors across 2023, including very fruitful visits from Dr Rhea-Silvia Remus and Lucas Kimmig from University Observatory Munich.



Postdoctoral Research Stefania Barsanti (ANU), Gabriella Quattropani (Macq) and Susie Tuntipong (U.Syd) change the plate on the Hector instrument on the Anglo Australian Telesope ready for observing. Credit: Nic Vevers ANU

Main image: Image of the inner parts of the Large Magellanic Cloud (LMC), the nearest and largest of the Milky Way's satellite galaxies. The first extremely metal-poor stars in the LMC have been discovered recently by ASTRO 3D and RSAA/ANU PhD student Wei Shen Oh (Oh et al., 2023 , MNRAS, 528, 1065 doi:10.1093/mnras/stae081). Credit: ESO

FIRST STARS

The Universe was created in the Big Bang some 13.8 billion years ago. A few hundred million years later the first stars formed. They were made up of only hydrogen, helium and trace amounts of lithium, but we know very little about their other properties. For example, how massive they were, how they influenced their surrounding environment, and how they ended their lives. The study of the nature and role of the first stars is therefore an important topic in modern cosmology and astrophysics.

The First Stars team aims to investigate the characteristics of the first stars through several different approaches, including performing supercomputer simulations to predict how the first stars formed and evolved. No genuine first stars are known at the present time. This likely indicates, in line with the simulation results, that the first stars were substantially more massive than the Sun. Massive stars have short lifetimes and thus no first stars could have survived to the present-day.

Simulations of how the first stars end their lives in supernova explosions are also carried out. These calculations are crucial, as the elements created by the nuclear reactions in the first stars are distributed by the supernova explosions into the surrounding interstellar gas, enriching it in elements such as carbon, oxygen and heavier elements. Low mass stars that then form from this enriched gas can survive to the present-day becoming the oldest stars we can study.

The team searches for and studies in detail these oldest stars measuring their chemical compositions. In particular, since different elements are made in different amounts in first stars of different mass, we can use the element abundances and element-to-element abundance ratios in the oldest stars to learn about the properties of the first stars. At the same time these studies allow us to understand how the chemical composition of the gas and stars (and planets) changed as our Galaxy evolved over time.

Project Highlights 2023

The detailed element abundances and element-to-element abundance ratios in extremely metal-poor stars (EMP stars; defined as those with iron abundances less than 1/1000th of the solar value, [Fe/H] ≤3) are frequently used to infer the characteristics of the first stars to form in the Universe. When these first stars end their lives, the resulting supernovae pollute the interstellar gas from which the EMP stars we observe today form. Using EMP stars to infer the properties of the first

stars, however, has an underlying assumption - that the present-day EMP star was formed in a gas cloud that was enriched by a single first star supernova. This is known as the mono-enrichment assumption. A recent paper, that included Partner Investigator Prof Chiaki Kobayashi (Univ. Hertfordshire, UK) as a co-author (Hartwig *et al.*, 2023, ApJ, 946, 20), investigated this assumption. Using a data-driven approach, the results suggested that only ~1/3rd of the EMP stars in the sample were mono-enriched. As illustrated in Figure 1, the probability of an EMP star being mono-enriched increases with decreasing metallicity and with enhancement of the carbon abundance. The results reinforce the need to find and observe the very rare lowest metallicity stars in order to properly constrain the properties of the first stars.

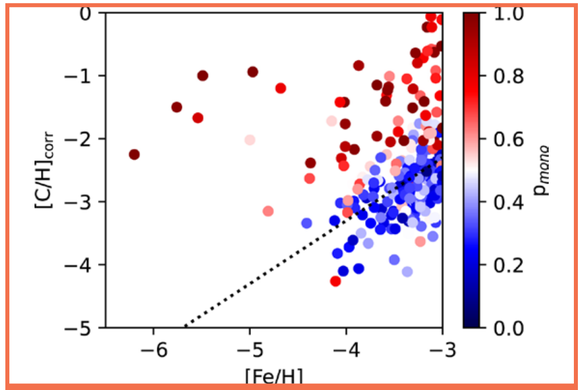


Figure 1. The carbon abundance ([C/H]) is plotted against the iron abundance ([Fe/H]) for the sample of extremely metal-poor (EMP) stars studied. The dashed line represents [C/Fe] = +0.7, above this line stars are considered to be enhanced in carbon. The colour-bar on the right shows the probability that the star has been enriched by a single supernova event (i.e., mono-enriched). The plot shows that carbon-rich and iron-poor stars have the highest chance of being mono-enriched objects. [Figure from Hartwig et al. ApJ].

The star SDSS J102915.14+172927.9 is regarded as the star with the lowest overall metallicity as not only does it have a very low iron abundance ([Fe/H] < -4), it also is not enhanced in carbon. In the paper Lagae *et al.*, 2023, A&A, A90 which includes ASTRO 3D Affliate Dr Karin Lind (Stockholm University, Sweden), and AIs Dr Thomas Nordlander (ANU) and Prof Alex Heger (Monash) as co-authors, the composition of this star was reanalyzed using a tailored three-dimensional model atmosphere. The model atmosphere was then used with a radiative transfer code to compute 3D non-local thermodynamic equilibrium (non-LTE) synthetic spectra allowing abundances and upper limits for a number of elements to be inferred. The abundances were found to be systematically higher than those found in earlier works. Specifically, the upper limit on the overall metallicity for this star is raised by a factor of two. The authors also found that the 3D non-LTE abundance pattern can be reproduced by Population III progenitors with masses of 10-20 Msun exploding with energy E ≤3 × 10^51 erg.

Despite it being the Galaxy's nearest and largest satellite galaxy, metal-poor stars in the Large Magellanic Cloud (LMC) have not been extensively studied. This situation has been addressed in a recent paper (Oh *et al.*, 2023 , *MNRAS*, 528, 1065 doi:10.1093/mnras/stae081) led by ASTRO 3D and ANU PhD student Wei Shen Oh, together with ASTRO 3D AIs Dr Thomas Nordlander (ANU), Prof Gary Da Costa (ANU), Prof Michael Bessell (ANU) and Dr Dougal Mackey (ANU). The paper presents a detailed abundance study of seven very and extremely metal-poor stars in the LMC. The study confirms that the stars, two of which have [Fe/H] < -3, are the most metal-poor stars so far discovered in the Magellanic Clouds. While the element abundance ratios for the LMC stars are generally consistent with those for Milky Way stars, the study found that two of the more metal-rich LMC stars are significantly enriched in r-process neutron-capture elements. The absence of r-process enrichment in the stars with lower [Fe/H] values implies a minimum delay timescale of ~100 Myr in the LMC prior to the initiation of the neutron star binary merger process that generates the substantial r-process enrichment.

In Howell et al, PhD student Maddy Howell (Monash) used Asteroseismology to Measure an Integrated Mass Loss for Evolved Stars in Globular Clusters. Asteroseismology provides a new avenue for accurately measuring the masses of evolved globular cluster stars. Maddy's work presents the first detections of solar-like oscillations in 47 red giant branch and early asymptotic giant branch stars in the metal-poor globular cluster M80; only the second with measured seismic masses. Howell et al., 2024, MNRAS, 527, 7974.

Other significant papers published by PhD students in the report year include: McKenzie *et al.*, 2023, MNRAS, in press; and Monty *et al.*, 2023, MNRAS, 518, 615.

Personnel Highlights 2023

ASTRO 3D and RSAA/ANU PhD student Madeleine McKenzie shared with RSAA PhD student Sarah Bradbury the ANU College of Science Service Award for Inclusion, Diversity, Equity and Access (IDEA). The citation reads 'Madeleine and Sarah have demonstrated exceptional commitment to fostering a welcoming and supportive environment within our academic community, including through the initiation and successful implementation of the Buddy program for PhD and Honours/Masters students at RSAA. Their collective efforts have not only enriched the academic experience for their peers, but have also set a precedent for mentorship, representation, and support that resonates with the core values of IDEA'.

New ASTRO 3D and ANU PhD student Ben Lowe has joined the First Stars team. Ben's thesis involves using the ANU 2.3m and the AAT 2dF/AAOmega facilities to search for extremely metal-poor (EMP) stars using a sample selected from the Gaia DR3 data release. Interesting candidates will then be followed up with ESO facilities including the X-Shooter and UVES VLT instruments. A particular focus of the program is the occurrence and characteristics of EMP stars that reside in the Galaxy's disk. Ben's supervisors are ASTRO 3D AIs Dr Luca Casagrande (ANU), Dr Thomas Nordlander (ANU), Prof Gary Da Costa (ANU) and Prof Norbert Christlieb (Univ. of Heidelberg, Germany).

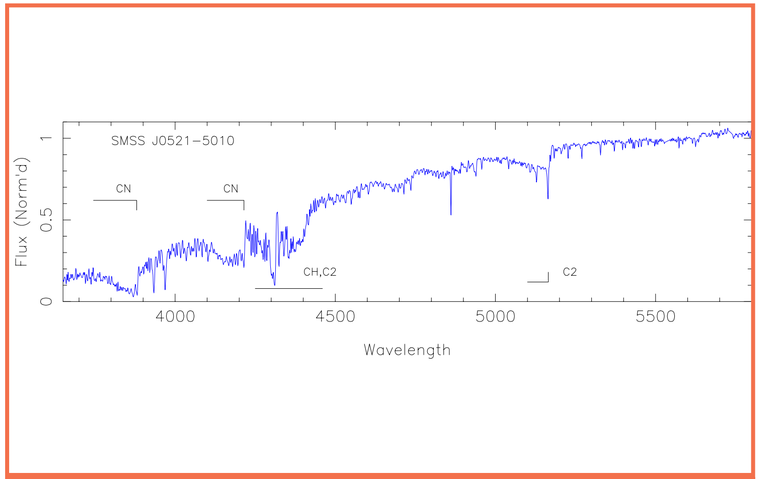


Figure 2. The ANU 2.3m telescope spectrum of the star GALAH DR3 171208003602224 (also known as SMSS J0521-5010 and HE 0520-5012). Marked on the plot are spectral features due to CN, CH and C_2 molecules in the star's atmosphere.

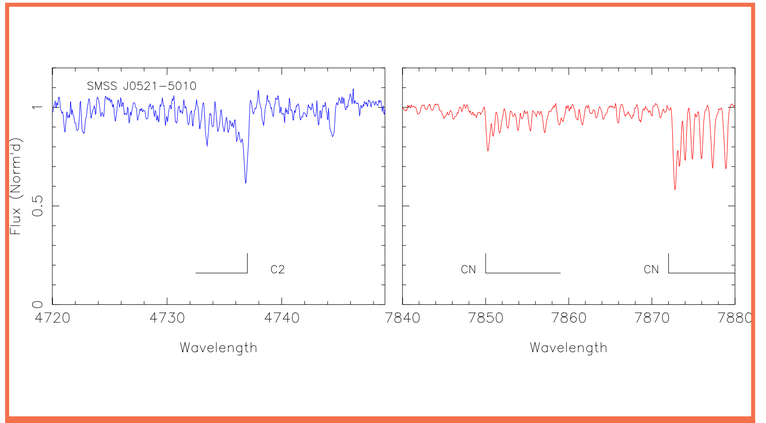


Figure 3. The GALAH blue and near-infrared band HERMES spectra of GALAH DR3 171208003602224. The C_2 feature with bandhead at 4737Å and the CN features with bandheads at 7850 and 7872Å are clearly visible. These features are now used to measure C and N abundances for GALAH stars, providing a much larger dataset for C than previously available and the first N abundance determinations.

ASTRO 3D and ANU PhD student Aldo Mura Guzman has been awarded his degree. Aldo's thesis was entitled 'Probing Nucleosynthesis and Chemical Properties: Infrared Spectroscopy in CEMP Stars and Obscured Star Clusters' and his principal supervisor was ASTRO 3D AI Dr David Yong (ANU).

ASTRO 3D and ANU PhD student Wei Shen Oh has submitted his PhD thesis. The thesis title is 'Investigating the Chemistry of Stars in the Large Magellanic Cloud'. Wei Shen's supervisors where ASTRO 3D AIs Dr Thomas Nordlander (ANU), Dr Dougal Mackey (ANU) and Prof Gary Da Costa (ANU).

At Monash University, PhD student Tanner Wilson submitted PhD thesis entitled 'Problems in Low-Mass Stellar Rotation'. Tanner was supervised by ASTRO 3D AIs Dr Andrew Casey (Monash) and Prof Ilya Mandel (Monash).

Cross-Project Collaborations 2023

In a recent paper (Da Costa *et al.*, 2023, MNRAS, 520, 917) in which candidate extremely metal-poor stars selected from the GALAH survey were followed-up with low resolution spectroscopy using the ANU 2.3m telescope, one star stood out as having extremely high abundances of carbon and nitrogen. The 2.3m spectrum of the star, GALAH DR3 171208003602224, is shown in Figure 2 where spectral features of CN, CH and C_2 are marked. The star has [Fe/H] = -2.1 and spectral synthesis applied to the 2.3m spectra suggest [C/Fe] = +1.3 and [N/Fe] = +1.9 (i.e., 20 times higher relative C abundance and almost 100 times higher relative N abundance compared to values for the Sun). This led us to investigate the GALAH blue and near-infrared band HERMES spectra for this star, which are shown in Figure 3. These spectra reveal a C_2 feature with a bandhead at 4737Å and CN features with bandheads at 7850Å and 7872Å leading to the recognition that these features could be used to measure C and N abundances in GALAH spectra. Previously, GALAH C abundances came only from measurements of a single neutral carbon absorption line (warmer stars only) while N abundances were not measured at all. However, as a result of this cross-project collaboration, the forthcoming GALAH DR4 release will contain C abundances for many more stars than previously, and it will contain N abundances for the first time.

GENESIS THEORETICAL SIMULATIONS

The ASTRO 3D Genesis Simulation program focuses on three key science areas:

- Simulating the birth of the first stars and their impact on early universe chemical enrichment, proto-galaxy formation, reionisation and the evolution of the IGM.
- Tracking galaxy growth through star formation and mergers, and the build-up of angular momentum at all galactic scales, leading to the emergence and evolution of large-scale structure and the epoch of quasars.
- Uncovering the history of the local galaxy population, including radio galaxies and AGN, by following the dynamical, stellar and chemical evolution of the galaxies across cosmic time to the present day.

These questions are being addressed through the concurrent development of a new generation of integrated N-body/ hydrodynamical galaxy formation simulations coupled to sophisticated semi-analytic galaxy models, the 'Genesis Suite'. Genesis will be available to both the ASTRO 3D and wider astronomical community through an update to the Theoretical Astrophysical Observatory (TAO++), opening up Genesis to be easily usable to address all the key ASTRO 3D science goals.

The Genesis Simulations thread combines suites of large N-body simulations that are coupled to semi-analytical models to produce synthetic galaxy populations across cosmic time, all run in-house, with bespoke analysis of state-of-the-art hydrodynamical simulations, such as EAGLE (Schaye *et al.* 2015) and Illustris-TNG (Pillepich *et al.* 2016), and their successors, and our own in-house runs targeting individual galaxies (both non-cosmological and cosmological zooms), which address specific problems with an ASTRO 3D focus.

Esteban Jimenez (ICRAR/UWA), who submitted his PhD thesis in late-2023, used the EAGLE cosmological simulations to study the evolution of the velocity dispersion of cold gas in disc galaxies and how it connected to stellar feedback, gravitational instabilities, cosmological gas accretion, and galaxy mergers. He found that the evolution of the predicted velocity dispersion as a function of stellar mass and star formation rate is in good agreement with observations - see Figure 1. By digging deeper into the simulations, Esteban was able to show that the velocity dispersion correlates most strongly with the specific gas accretion rate onto the galaxy and the degree of misalignment between the inflowing gas and the rotation axis of the galaxy. These results are striking because they reveal that gas accretion, and not feedback from stars, are likely the driver of observationally inferred turbulence in galaxies

PhD student Sabrina Berger (U Melbourne) has been using the BlueTides simulation to study the hosts of low luminosity quasars at high redshifts and comparing to two quasars recently detected by the JWST - J2255+0251 and J2236+0032. She has investigated the physical implications of the measured properties of J2255+0251 and J2236+0032 by finding analogues in BlueTides at redshift z = 6.5 and shown that the observed quasars are consistent with the predicted stellar to black hole mass relation, having similar luminosities to the brightest simulated quasars. By constructing mock observations (Figure 2), Sabrina has recovered host images that are consistent with those observed for J2255+0251 and J2236+0032, strengthening the weight of evidence in favour of the interpretation from BlueTides.

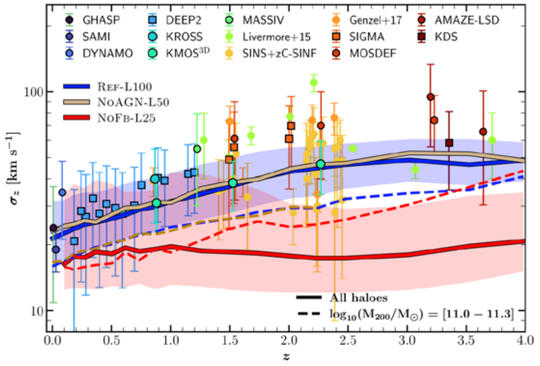


Figure 1. Figure 1 - evolution of the gas velocity dispersion in simulated galaxies (in EAGLE runs with varying parameters) as a function of redshift, compared to observational data. From Jimenez et al. 2023.

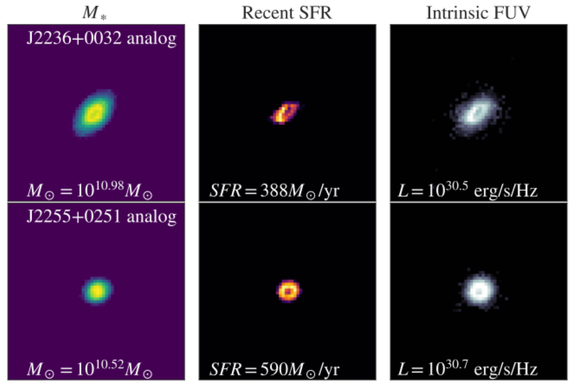


Figure 2. mock images (rest frame) of the JWST observed quasars. From Berger et al. 2024.

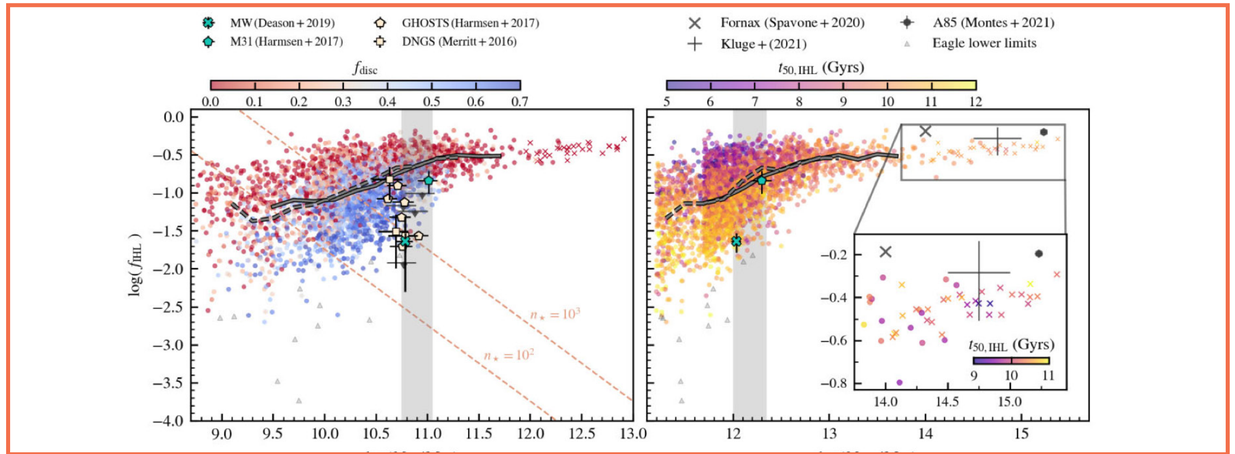


Figure 3. The fraction of IHL in galaxies and halos increases with increasing mass, with a scatter broadly consistent with observations. From Proctor et al. 2023.

PhD student Katy Proctor (ICRAR/UWA) has investigated the intra-halo light (IHL) of galaxies, groups, and clusters in cosmological simulations using a technique for the structural decomposition based on application of Gaussian mixture models to the kinematics of star particles. She showed that the IHL fraction as a function of galaxy and halo mass has an appreciable scatter, which strongly correlates with galaxy morphology. At a given stellar mass, the IHL fraction of galaxy discs tends to be older and less massive than that of spheroidal galaxies (see Figure 3).

Tyler Houston, Darren Croton, and Manodeep Sinha (Swinburne UT) used the SAGE semi-analytical model to look at quiescent (central) and assess long galaxies spend in this phase as they transition off the star forming main sequence. Interestingly, they find periods of quiescence are most marked for galaxies at the lowest and highest masses (see Figure 4) - dropping from ~45% of galaxies at low masses, to ~10% at intermediate masses, to ~25% at high masses. Quiescence at low masses is driven by periods of supernova feedback, which can lead to these systems undergoing multiple periods of quiescence, while at high masses it is AGN feedback that is the driver; once quiescent, these high mass galaxies tend to remain so.

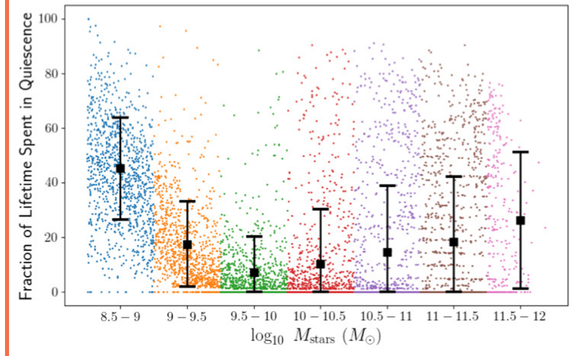
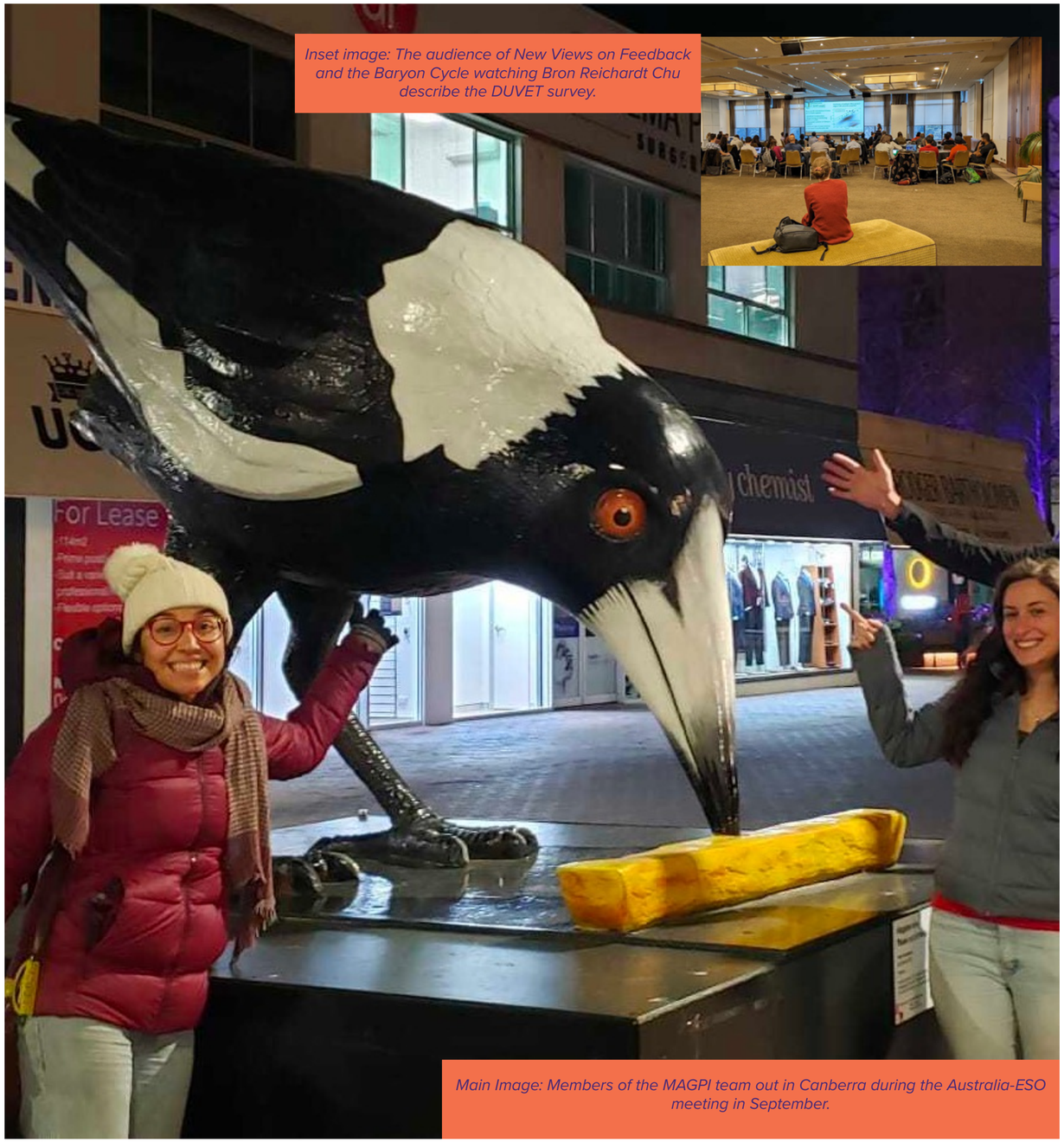


Figure 4. The average time a galaxy is predicted to spend in a quiescent state, as a fraction of its age. From Houston et al. 2023.



Inset image: The audience of New Views on Feedback and the Baryon Cycle watching Bron Reichardt Chu describe the DUVET survey.

Main Image: Members of the MAGPI team out in Canberra during the Australia-ESO meeting in September.

GALAXY EVOLUTION

The Galaxy Evolution Project aims to understand the main themes of ASTRO 3D: the build up of matter, the ionisation of the Universe and the creation and distribution of the elements not just in one program but across the history of the Universe. Unlike other projects, Galaxy Evolution uses a variety of smaller projects to make a comprehensive picture. Those projects include but are not limited to: XQR-30, DUVET, MAGPI, AGEL.

XQR-30 uses the Very Large Telescope to study the properties of ionization in the cosmos shortly after reionisation (z=5-6). It does this by observing absorption lines toward quasars that are located at higher redshift. Those absorption lines probe the gas along the line-of-sight and reveal how the early Universe became ionised.

DUVET is trying to understand the physics of winds that carry gas away from galaxies. They use observations from KCWI on the Keck telescope to study nearby galaxies with extremely high star formation rates. Because they are so nearby and because the KCWI instrument on Keck is very sensitive, DUVET can target extremely faint features in the spectrum. This opens the window to studying the physics of the faint gas that is outside of the galaxy itself. DUVET observations act as laboratories for understanding processes that are critical for the evolution of all galaxies at all redshifts, yet because the emission lines are so faint they have historically not been well studied.

MAGPI aims to study spatially-resolved ionised gas, mass and dynamics of galaxies 3-4 Gyr ago. The focus on this time period makes MAGPI unique, as many projects focus on galaxies in the local universe or (for technical reasons) 7-10 Gyr ago. The epoch that MAGPI targets remains poorly studied. The MAGPI team uses observations from the MUSE on the Very Large Telescope to target hundreds of galaxies in order to reveal the distribution and kinematics of matter. MAGPI observations are aided by adaptive optics (laser systems used to increase the spatial resolution of astronomical data) to increase data quality. The science aims of MAGPI align very well with ASTRO 3D: (1) understanding the stellar and gas angular momentum evolution of galaxies; (2) discerning the environmental impact; (3) understanding the role of gas and galaxy accretion; and (4) constraining energy sources and feedback activity.

AGEL uses deeper and higher resolution images of DESI DR9 and DECals survey to identify lensing candidates using machine learning plus visual inspection. AGEL has identified lenses which were fainter, not previously identified in other surveys and at higher redshifts.

Project Highlights

In 2023 members of the Galaxy Evolution project organised multiple international meetings utilising ASTRO 3D funds. These brought in researchers from around the world and highlighted ASTRO 3D researchers, as well as built an understanding of research critical to ASTRO 3D.

New Views on Feedback and the Baryon Cycle – This was a specialty conference on feedback and outflows organized by Deanne Fisher and Rebecca Davies. The meeting took place in Healesville, VIC. The call for abstracts received 3 times the number of applicants that we had space for. The meeting was a great success, with high-profile participants travelling from around the world. ASTRO 3D had a strong presence giving multiple talks, including multiple invited talks.

Galaxy Transformation Across Space and Time – This was the third ESO-Australia conference, which took place at the Australian Academy of Science in Canberra. It was organised by Emily Wisnioski and Trevor Mendel. The meeting was attended by members of the government. Along with exciting science on a variety of topics, significant discussion took place around the future of Australian astronomy.

The Galaxy Evolution team had great success in international and space-based telescope proposals. Andrew Battisti successfully proposed for HST observations to measure the properties of dust in MAGPI galaxies. Tania Barone successfully proposed for JWST and HST observations of two AGEL galaxies to measure low mass stars that are needed to constrain the stellar initial mass function.

In 2023 the First Galaxies project merged with Galaxy Evolution. Following the successful launch of the James Webb Space Telescope, ASTRO 3D has published 78 articles this year with “JWST” in the title! A highlight is the early results from GLASS-JWST, focusing on rest-frame UV-optical Properties of Galaxies at 7 < z < 9, led by Nicha Leethochawalit. The work presents the largest survey of galactic properties at redshift 7 to 9 (during the peak of the reionisation of hydrogen in the Universe), and uses their measured spectra to model their ionising radiation history, indicating that this population started producing their ionising radiation at z>9.5. Surveys such as these allow deep analysis of the properties of galaxies that are responsible for transforming the early Universe.

Rebecca Davies had a press release titled 'Tracing 13 billion years of history by the light of ancient quasars' that covered her work on the VLT/X-Shooter Large Program in which she measured the largest sample of high-redshift absorption lines.

Project Personnel Highlights

PhD students Bron Reichardt Chu and Juan Salcedo Espejo, both from Swinburne, completed their PhDs this year. See PhD Completions on page 57 for more information.

New Member: Rory Elliott (Swinburne)

Rebecca Davies (Swinburne) was awarded a DECRA Fellowship

Cross-Project Collaborations

The most significant cross-project collaboration for the Galaxy Evolution project is GECKOS, which uses observations from MUSE to understand the physical processes that drive the evolution of disk galaxies. This is a new project not officially covered under ASTRO 3D but it connects Galaxy Evolution members to other projects. The lead team include: Deanne Fisher (Galaxy Evolution), Jesse van de Sande and Amelia Fraser-McKelvie (SAMI/HECTOR), and Michael Hayden (GALAH). While the program is ongoing and too early for publications, postdoc Barbara Mazzilli Ciraulo is working on a paper that combines GECKOS and WALLABY observations.

AUSTRALIAN SKA PATHFINDER SURVEYS (ASKAP)

The Australian SKA Pathfinder (ASKAP) Surveys project is investigating the evolution and buildup of neutral hydrogen (HI) in galaxies over the past 7 billion years.

HI provides the reservoir of material from which new stars can form in galaxies, and so is key to understanding how galaxies evolve over cosmic time. ASTRO 3D researchers are members of three different but interlinked ASKAP surveys: DINGO, FLASH and WALLABY.

The Deep Investigations of Neutral Gas Origins (DINGO) survey (led by AI Martin Meyer) is studying the evolution of galaxies and the gas-rich Universe over the past 4 billion years. This will be achieved through both the direct detection of galaxies in the nearby Universe as well as statistical stacking studies at higher redshifts. The HI emission line data from DINGO will be combined with extensive multiwavelength data available in the GAMA G23h field to understand the connections between gas content, stellar populations and star formation history, and the underlying dark matter distribution.

The Widefield ASKAP L-band Legacy All-sky Blind surveY (WALLABY) (led by CIs Barbara Catinella and Lister Staveley-Smith) aims to detect 200,000 nearby galaxies (with a mean redshift of about 0.04) across the southern hemisphere. The goals of WALLABY include measurement of baryonic and dark matter mass profiles of unprecedentedly large galaxy samples and studying the effect of environment (local galaxy and gas density) on the properties of galaxies in order to better understand galaxy evolution in cosmic voids, filaments, groups and clusters.

The First Large Absorption Survey in HI (FLASH) (led by CI Elaine Sadler and AI Elizabeth Mahony) uses measurements of the 21cm HI line seen in absorption against bright background radio sources to study neutral gas in and around distant galaxies. With this technique, FLASH will probe the HI gas content of several hundred individual galaxies and study the evolution of HI over the past 4-8 billion years, where the HI emission line is too faint to be detected in even the deepest ASKAP surveys.

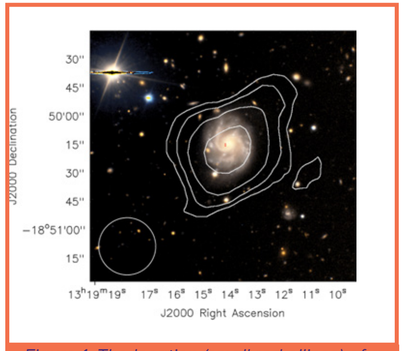


Figure 1. The location (small red ellipse) of a Fast Radio Burst near the nucleus of a host galaxy also detected by WALLABY in neutral hydrogen (Glowacki et al. 2023, ApJ, 949, 25)

Project Highlights 2023

WALLABY obtained its first full year of full survey science operations in 2023. Due to issues with the Setonix supercomputer and unexpectedly high solar activity, only 19 footprints were able to pass quality assurance, and only 4 dual-footprint tiles were obtained. The Australian SKA Regional Centre (AusSRC) supported post-processing pipeline, incorporating the SoFIA source-finder, was used to catalogue 1700 galaxies from the data obtained. 500 galaxies were catalogued in the full-depth tiles. The WALLABY team published eight team papers this year, including two led by ASTRO 3D members Tristan Reynolds and Bi-Qing For. There was also huge media interest in two WALLABY publications: (1) Marcin Glowacki's paper, which described the discovery of a Fast Radio Burst in a WALLABY field in which the host galaxy's HI emission was also detected (see Fig.1); (2) Nathan Deg's paper, which describes the discovery of two new polar ring galaxies (see Fig.2). Much effort has also been put into the impending Public Data Release 2 of WALLABY pilot data. This release includes high resolution (12 arcsec, as opposed to the standard 30 arcsec) images for a subset of the detections, expected to be published in 2024. Further implementation of the 12 arcsec pipeline is being jointly supported by ASTRO 3D and ICRAR.

Figure 2. Polar ring galaxy discovered by WALLABY (Deg et al. 2023, MNRAS, 525, 4663)

Following on from the reduction of its pilot phase II data, DINGO produced the associated HI catalogues and data products, demonstrating significantly improved source counts over the initial pilot phase I data reduction. Using this experience, the team returned to the pilot phase I data to reprocess this in a consistent manner. In another major milestone for the project, the first observations of the full 3200h main-survey allocation were taken at the end of the year, enabled by large storage and computer allocations obtained as part of PaCER. On the science front, PhD student Ajay Dev published his first thesis paper on the HI-halo mass relation using HI stacking, with a view to subsequent analysis using DINGO.

FLASH also completed its first full year of full ASKAP survey operations, with 42 survey fields (covering around 1600 square degrees of sky) so far processed, validated and released. Through our collaboration with the AusSRC, we have begun automating the processes needed to run the FLASH linefinder and produce spectral plots and line lists. These will be saved in a new FLASH database at AusSRC, allowing us to analyse the new data more efficiently and streamline public access to the FLASH data products. A paper led by ASTRO 3D postdoc J.N.H.S. Aditya reported 3 new HI absorption systems detected in a subset of the FLASH pilot-survey, including the strongest HI absorption system found to date (see Fig. 4).

Analysis of the FLASH Pilot Survey data also continued in 2023, and we held a FLASH Busy Week at CSIRO in Sydney from 20-24 November to work on the final data products and papers from the pilot survey. The FLASH team were also awarded observing time with the South African MeerKAT telescope, the Long Baseline Array (LBA) and the US VLBA and UK eMerlin VLBI arrays for follow-up observations of HI absorption-line systems detected in the pilot survey.

Personnel Highlights

PhD candidate Manasvee Saraf continues her WALLABY-related project. Seona Lee started her PhD on WALLABY in 2023. Two new ASTRO 3D PhD students will join the WALLABY team in 2024, creating a lasting legacy for ASTRO 3D.

Jonghwan Rhee completed his position as an ASTRO 3D researcher for DINGO. Many thanks to Jonghwan for all his excellent work over the years in this role. Jonghwan nevertheless remains very much engaged with DINGO as part of its core team.

FLASH Project Scientist Dr Hyein Yoon moved to Korea at the end of 2023 to take up a five-year LAMP postdoctoral position at Seoul National University (SNU). Hyein made enormous contributions to ASTRO 3D and the FLASH project during her time as an ASTRO 3D researcher at the University of Sydney, and we are delighted that she will continue her involvement with FLASH in this new role. FLASH PhD student Renzhi Su successfully defended his PhD thesis, supervised jointly at Shanghai Astronomical Observatory and CSIRO.

ASTRO 3D PhD student Simon Weng returned from Garching after spending two years in Germany on an ESO Studentship, and PhD student Emily Kerrison also spent time in Europe this year, visiting the eROSITA group in Munich and our ASTRO 3D partner institute ASTRON in the Netherlands.

Figure 3. FLASH team members at their Busy Week in Sydney, November 2023

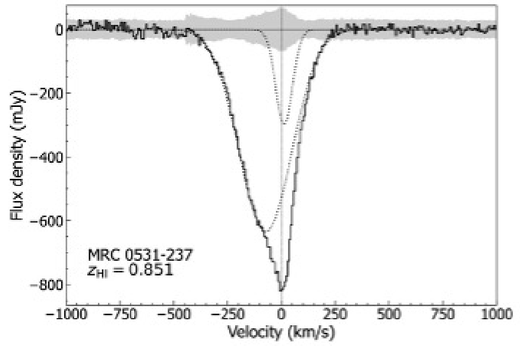


Figure 4. FLASH Pilot Survey detection of a strong 21cm HI absorption line associated with the powerful radio galaxy MRC 0531-237 at redshift z=0.85, published by Aditya et al. (2024, MNRAS 527, 8511). This is the strongest 21cm absorber published to date with an integrated optical depth of 143 km/s.

Cross-Project Collaborations

ASTRO 3D members gave WALLABY and FLASH presentations at several meetings during the year, including the ESO/SKA meeting Coordinated Surveys of the Southern Sky (February 27 to March 3 in Garching), the Pathfinders HI Survey Coordination Committee workshop (March 27 to 31, Cape Town), the ASTRO 3D science meeting (May 30 to June 1, Fremantle), the Annual Scientific Meeting of the Astronomical Society of Australia (July 3 to 7, Sydney), New Views on Feedback & the Baryon Cycle in Galaxies (July 17 to 21, Healesville), ACAMAR Gas in Galaxies (July 25 to 28, Perth), ACAMAR 9 (July 31 to August 4, Perth), the Evolution of Gas in and around Galaxies (July 31 to August 4, Stanley), the Asia-Pacific IAU Regional Meeting (August 7 to 11, Koriyama), the URSI General Assembly (August 21 to 25, Sapporo), the ATNF Colloquium (September 6, Sydney), Galaxy Transformation Across Space and Time (September 11-15, Canberra), and SKA in Korea (October 30 to November 3). Ongoing collaborations continue with the SAMI/HECTOR team, the DIAP/Data Central team and the Genesis team.

DINGO continued its collaborations with other ASKAP surveys through the spectral-line working group, as well as collaborative efforts with AusSRC and Pawsey as part of the HIVIS PaCER project.

DATA INTENSIVE ASTRONOMY (DIA)

The Data Intensive Astronomy (DIA) program facilitates better access to tools, technology, infrastructure and training for ASTRO 3D researchers working with large datasets and in high-performance computing environments.

This is achieved by working with national infrastructure providers and facilitating the sharing of expertise between ASTRO 3D researchers. Much of the ASTRO 3D science involves world-leading surveys and large data sets, making our ability to process these data in a timely and efficient manner critical to the success of the Centre.

The DIA program facilitates collaboration on key data sets across the ASTRO 3D program through the e-research platform developed and maintained by Data Central - part of Australian Astronomical Optics (AAO) hosted at Macquarie University, and partnering with ASTRO 3D. Data Central hosts several ASTRO 3D survey data sets, including SAMI, GALAH, MAGPI, and the Hector Galaxy Survey, providing collaborative data access, wiki hosting, and public data releases. Data Central works closely with other key national digital infrastructure providers, including the Australian Square Kilometre Array (SKA) Regional Centre (AusSRC) – a joint venture between CSIRO, Pawsey Supercomputing Research Centre, Curtin University, and the University of Western Australia that forms part of an international network supporting the global flow of data and processing needed for the SKA telescopes.

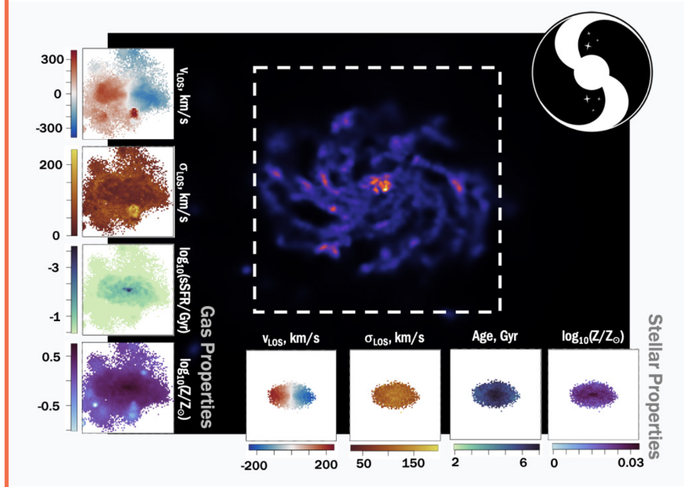


Figure 1. SimSpin.png: Example of simulated outputs from SimSpin. The central image shows the projected gas density for a galaxy at low redshift from the EAGLE simulations. Lower panels show derived stellar population and kinematic properties. Vertical panels show simulated gas kinematics, star formation rates and metallicity.

Project Highlights 2023

Data Central embarked on a major overhaul of its software to improve reliability, maintainability and scalability. The first phase of this work was completed in 2023; this involved a redesign of the backend software to improve data ingestion, and eventually allow research teams to manage the ingestion of their own data. We also set up a new and improved VO-compliant Table Access Protocol (TAP) service, which allows users to upload their own data for cross matching with other Data Central-held data. The next phase of the overhaul will involve significant improvements to the web portal for Data Central, integrating both data management and team-support capabilities into one platform.

The team also supported several ESO large programs, including MAUVE, GECKOS and MAGPI. This involved providing significant compute access for the large-scale data reduction required for the MUSE instrument. Additionally we continue to provide support for the Hector, GALAH and Veloce science teams through various web services.

Personnel Highlights 2023

Dr Karen Lee-Waddell (ICRAR/CSIRO) received the 2023 Western Australia Young Tall Poppy Science Award for outstanding early career research. As Director of the Australian SKA Regional Centre, Dr Lee-Waddell is leading the Australian effort to build computing and data intensive research capabilities to support astronomers using current and next generation radio telescopes. She is also the Project Scientist for WALLABY, the all-sky survey that aims to detect and image the gas distribution in hundreds of thousands of galaxies using CSIRO's ASKAP telescope.

Following a productive year as a DIA postdoc at Macquarie University, Dr Suk Yee Yong successfully obtained an ongoing position as a Scientific Computing Specialist in Machine Learning at CSIRO's Information Management and Technology team. Suk Yee brought a unique skillset to the DIA team around data science techniques for astrophysical data sets, and remains active in astronomy research, with a recently published paper studying the application of conformalised quantile regression (CQR) to quantify the uncertainties of the black hole predictions in a machine learning setting.

Cross-Project Collaborations

This year, a major milestone for the SimSpin data cube simulation tool was reached, with the publication of a comprehensive paper describing the methodology and functionality of the tool (Harborne *et al.* 2023). The functionality of SimSpin is currently being extended to permit the simple generation of multi-galaxy samples based on publicly accessible simulation suites, such as IllustrisTNG. This extension is being developed with resources from the Astronomy Data and Computing Services (ADACS) – a uniquely Australian capability, resourced by national infrastructure funding (NCRIS), that provides merit-based access to professional software developers. The ADACS project is led by DIA postdoc Sam Vaughan, in collaboration with ASTRO 3D postdoc Kate Harborne.

There has been ongoing coordination within the DIA group between cross-disciplinary partners ICRAR/Pawsey, AusSRC and Data Central, advancing ASKAP and SKA-related data pipeline operational modes, and developing tools for cross-matching of optical to radio source catalogues through remote server queries. ASTRO 3D DIA is also supporting the WALLABY team through software development for an innovative high-resolution pipeline, which allows subregions of WALLABY fields around objects of interest to be produced with effectively smaller beam sizes, facilitating improved synergies with e.g. optical surveys.

Figure 2. Example of cross-survey data aggregation tools developed by Data Central. The left panel shows a tool to select data from various optical and radio surveys (in this case, data from the all-sky MWA survey GLEAM-X is being selected for cross matching with GAMA catalogs). The right panel shows an example of how such data queries are returned and visualised.

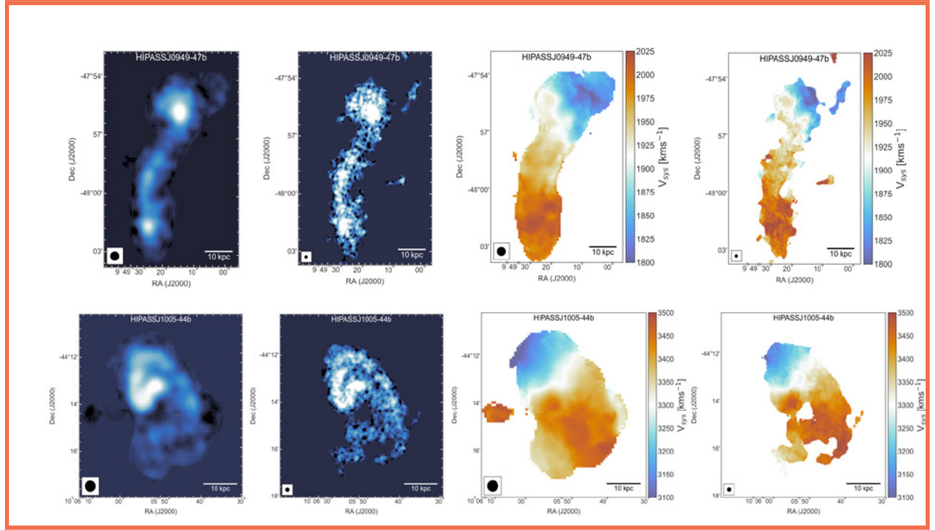
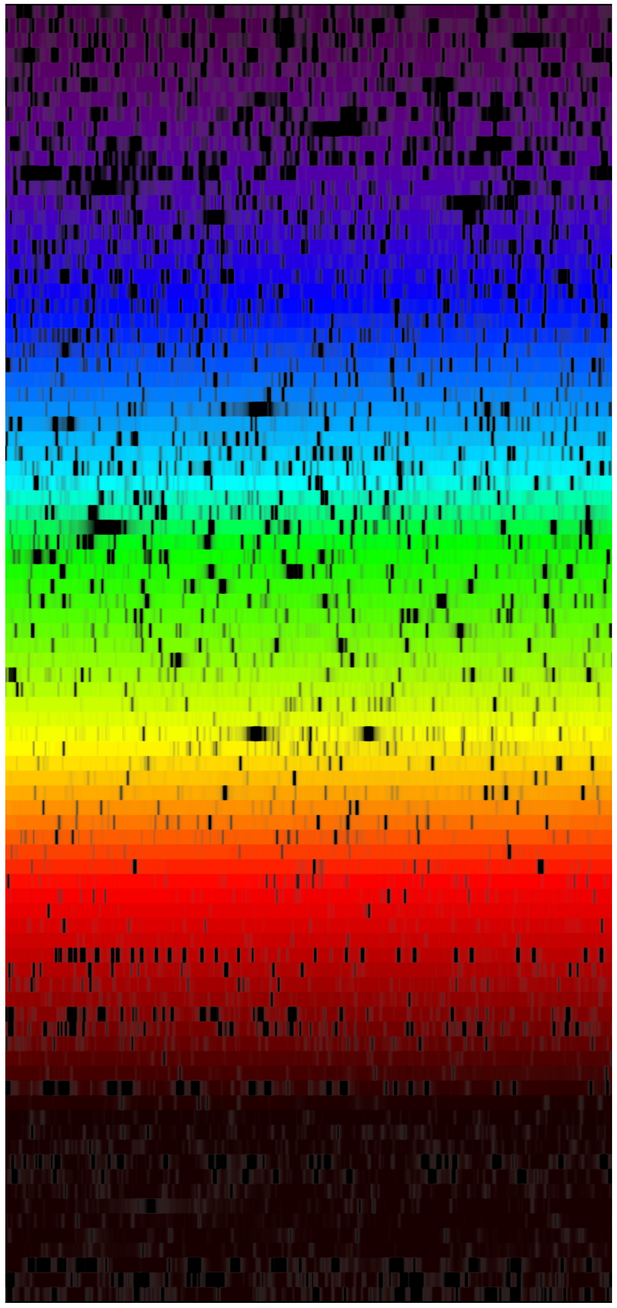


Figure 3. Examples of increased resolution (decreased beam size) HI maps for two galaxies cut out from the WALLABY Survey (one galaxy per row). The left two columns show the integrated HI intensity with the default WALLABY beam size (30" - left-most column), and the custom high-resolution beam size (10" - right-most column). The right two columns show the same information, but for the mean velocity of the HI gas.



GALACTIC ARCHAEOLOGY WITH HERMES (GALAH)

With ongoing 2dF problems at the telescope, this has been a year for focussing on GALAH science rather than finishing off the remaining <10% of GALAH observations.

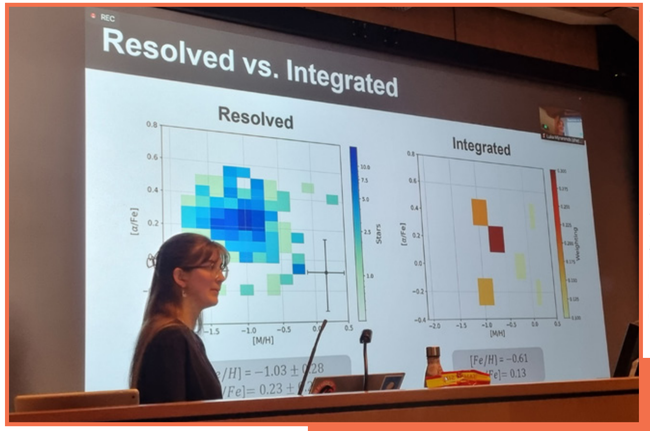
Fellow Sven Buder leads the work needed for the GALAH DR4 data release; a major research paper describing the results is in the works and the internal data release has just been made available to the collaboration during the ASTRO 3D GALAH/First Stars Meeting at Monash University on 12 February 2024. There are many improvements over previous releases and the team is excited about publishing the catalogue with almost 1 million stars during 2024. A focus has been improved stellar ages, which are critical for galactical archaeology.

As a byproduct of his PhD, Shourya Khanna published a paper with AI Michael Hayden and AI Sanjib Sharma on new evidence for stellar streaming motions in the galactic disc. Dr Janez Kos (Ljubljana), a GALAH team member, is finding evidence that open clusters in the disc have tidal tails; some are quite spectacular. This effect is already known to occur for globular clusters in the Galactic halo, e.g. Pal 5. Also from the Slovenian group, Vogrincic *et al.* (2023) have discovered new interstellar bands – mysterious unexplained spectral features – in the GALAH spectra arising from the ISM.

One of the most exciting developments is the use of 3D non-local thermodynamic equilibrium (NLTE) models to obtain better Li abundances in stars, following on from earlier work by Affiliate Karin Lind and her team. GALAH is uniquely placed to explore how Li is destroyed within stars in cosmic time. PhD student Ella Wang and team have achieved 230,000 Li detections and 350,000 upper limits from a catalogue of 580,000 stars. For the first time, they can track 'Li dip' stars (strong Li depletion) off the main sequence and up into the subgiant branch. This will inform future stellar models.

More and more, we are seeing independent groups extract exciting new science from earlier releases. For example, Nepal *et al.* (2024) have used GALAH data to show that there is an old, thin, alpha-poor disc that possibly dates back to 13 Gyr; much earlier than previous claims of the oldest alpha-poor stars being about 10 Gyr. This is particularly exciting in the context of JWST's discoveries of early thin discs, and numerous other claims of old disc components in the Milky Way. The GALAH team will be uniquely positioned to check these results with the final DR4 release.

Looking to the year ahead, much of our interpretation of GALAH/Gaia data will require a new class of dynamical models for the Galaxy. With the award of 1M Gadi supercomputer hours, Thor Tepper-Garcia and PhD Pavadol Yamsiri are exploring new turbulent gas disk models to see if the 'phase spiral' discovered by ESA Gaia would survive in a more realistic treatment of an galactic disc N-body model. If the phase spiral does not appear in the new models, this calls into question many of the ongoing explanations, i.e. that it was triggered by a strong merger event. These same models are being explored with the GALAH team to understand how the alpha-rich disc (formerly 'thick disc') emerged in the early universe. This disc has a vertical stellar dispersion of >50 km/s which we are not able to reproduce in our most turbulent disc models, because these are blowing themselves apart due to the huge star formation rates. There are many implications to explore as a result of the new work led by Tepper-Garcia.



ASTRO 3D Honours student Luka Mijnarends (supervised by Sven Buder from the GALAH project and Trevor Mendel from Galaxy Evolution) finished her interdisciplinary Honours project of resolved and unresolved stellar spectroscopy with MUSE.

ASTRO 3D Honours student Anne Xie (supervised by Sven Buder) finished her Honours project on investigating the differences in oxygen abundances between the GALAH and APOGEE surveys.

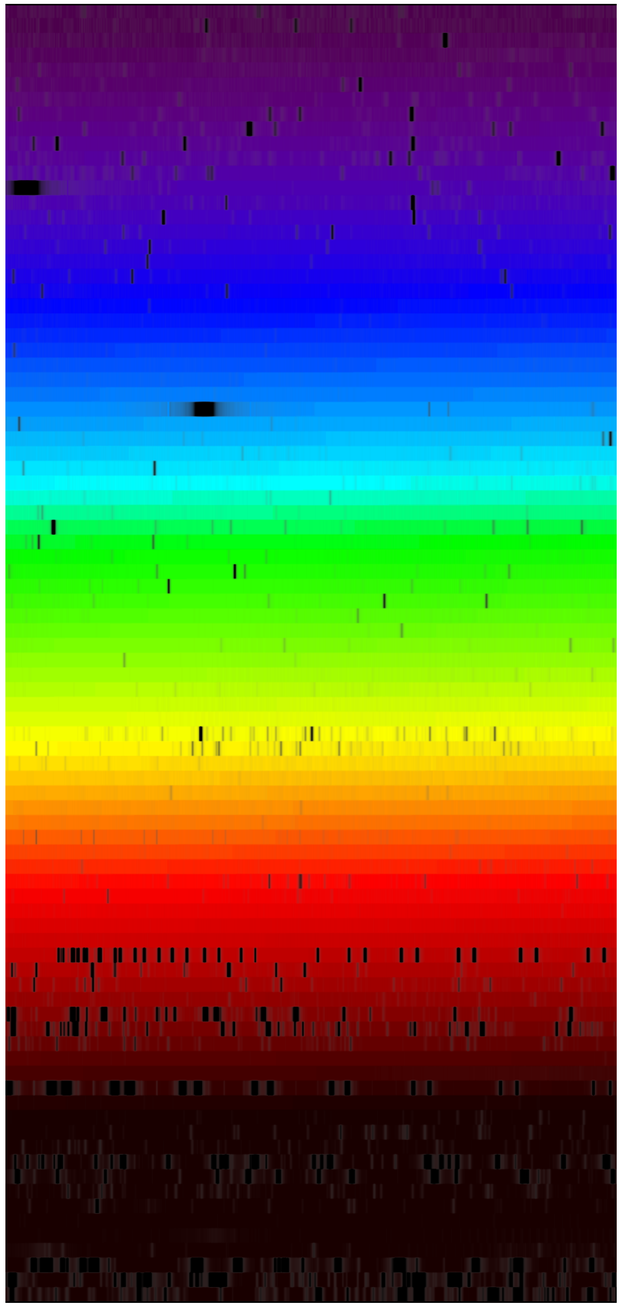
Images:

Centre. Honours student Luka Mijnarends presents the results of her interdisciplinary research of resolved and unresolved stellar spectroscopy - a pilot project between the GALAH and Galaxy Evolution streams to uncover the origins of elements for more distant galaxies than our Milky Way.

Far left. The light of the metal-rich star Alpha Centauri A (which points towards the Southern Cross) and (Far right) the 600 times more metal-poor star HD 140283 when split into its constituent wavelengths with the Veloce spectrograph attached to the Anglo-Australian Telescope.

Metal-rich and metal-poor refers to the amount of elements heavier than hydrogen and helium - and the difference of a factor 600 impressively manifests itself in the large amount of absorption features in Alpha Centauri A when compared to HD 140283.

These stellar fingerprints allow galactic archaeologists to map the chemical patterns of millions of stars and their evolution to better understand the origin of elements in the Milky Way and beyond.



2023 MEMBER SPOTLIGHTS

MADDIE McKENZIE

PHD STUDENT AT THE AUSTRALIAN NATIONAL UNIVERSITY

MY RESEARCH

I study the dinosaur bones of the Milky Way called globular clusters. I analyse the abundances of elements inside the oldest objects that we can accurately age; globular clusters. I do this using spectra from the Very Large Telescope, and HERMES spectra from the GALAH survey. This will shed light on how these collections of stars formed in the early Universe.

2023 HIGHLIGHTS FOR ME

Going on a two month long "odyssey" around the United States and meeting some of my astronomy idols.

WHY ASTRONOMY?

Astronomy is a childhood dream that I never let go of. I still can't believe that it's my job to look at stars every day.

IN MY SPARE TIME

I spend my free time ice skating, rollerskating, rock climbing, running and doing aerial acrobatics. I'm not particularly good at any of it, but is something to get me away from my desk.

IF I WASN'T DOING ASTRONOMY

If I weren't an astronomer, I would love to be a professional volleyball player (but I don't have the skills for it, so it's great that Astronomy has been working out :D).

MY CELEBRITY FRIEND WOULD BE

Taylor Swift - for obvious reasons.

BEST ADVICE I'VE BEEN GIVEN

From John Norris based on advice from his Ph.D. supervisor Leonard Searle: “You may be diffident about being that bold, but it is better to be interesting than right in science. (A half-truth, but worth keeping in mind.)”

ADITI VIJAYAN

ASSOCIATE INVESTIGATOR AT THE AUSTRALIAN NATIONAL UNIVERSITY

MY RESEARCH

I am Aditi, a PostDoc at ANU, an occasional poet and a self appointed curator of novels. I study outflows generated from supernova activity in star-forming galaxies. I use HD and MHD simulations to understand the features of the outflowing gas. During my PhD, I looked at X-ray and radio signatures of these outflows. In the (almost) two years as a Post-Doc at ANU, I have focussed on the problem of metal loading in the outflows. I run simulations of a patch of the Milky Way disc using the GPU-based code, Quokka. In our latest paper, which originally had a creative (read humorously long) title, we quantified metal loading in the SN-generated outflows. We were able to show how the degree to which the outflowing gas is loaded depends on how metal-poor/ rich the host galaxy is. Rongjun, a Master's student at ANU is currently working to generate mock observations using our simulation data.

2023 HIGHLIGHTS FOR ME

2023 will always be etched in my memory as the first full year I spent outside India. Though my life in Canberra shares little with the kind of life I used to have, I began feeling at home at ANU and in Canberra in 2023. This feeling was cemented by the love and support my Shirty Science t-shirt, Beyond the Galaxy, got. It was a truly humbling moment to see myself being cheered by so many not only at RSAA, but also ASTRO 3D and ANU. The true cherry on top of this already massive cake of 2023 was getting the first science paper out of Quokka. Building a new code is not a walk in the park. The Shakka (a group of quokkas is called a Shakka!) had been working really hard on it for years before I came onto the scene. To get a science result out of a new code, that is not just reproducing the existing knowledge more efficiently but also questioning the existing paradigm of what we know about metal transport, is a win for the Shakka in general and for me in particular. Can’t wait for all the amazing science we will get out of Quokka in 2024!

WHY ASTRONOMY?

During my Masters, I got a taste of a variety of branches in physics. I had a couple of hard-core theory courses which were quite intense and not entirely enjoyable. I did my project in a materials lab and I quickly concluded that any kind of lab work wasn't my cup of tea. When I started looking for PhD positions, computational astronomy had the correct balance of being physics-y but without the intensity of pure theory. I loved coding and the promise of not being in a lab sealed the deal for me. The most incredible thing about astronomy is how simple laws of conservation, which is what astrophysical code implements, can predict the behaviour of massive systems such as galaxies and clusters.

IN MY SPARE TIME

I am a compulsive writer, always have been. I grew up writing short sories and cringey poems and I've been journaling since I was twelve. I've kept a blog for more than a decade now on which I share my rants about bad books I've read, some flash fiction, and perhaps some rhymes. I think I express myself the best when I am writing and if I were to get stranded on a remote island, a pen and infinite paper is all I'd ask for!

IF I WASN'T DOING ASTRONOMY

A cafe owner, no doubt. In 2021, my dear friend Miao and I were in a weird transition zone where we weren't jobless but couldn't start astronomy... our respective positions because of Covid. During one of our catchup/ morale-boosting sessions, we had an epiphany of opening an astro-themed cafe in picturesque rural France. The menu was to boast of items like "Hubble Ice Tea", "Southern Crossaints" and "Ber-LINERs". I think I will circle back to this at some point in time.

MY CELEBRITY FRIEND WOULD BE

I am not sure if this counts as a celebrity, but I would like to be friends with General Iroh from Avatar, the Last Airbender. He is charming, wise, intelligent, and easy going in equal measure. His tea making skills are legendary and as tea-enthusiast I think we are wellmatched in this respect. We both like to take it easy and I am sure we would keep each other good company lounging in an Earth kingdom hot spring.

BEST ADVICE I'VE BEEN GIVEN

Miao, my future cafe partner, gave me a piece of advice which I've made my mantra for life. When I was unsure about a career in astronomy, given that uncertainty is an integral part of this journey, she said instead of obsessing over what might and mightn't happen, I should take a step back and figure out what is within and beyond my control. Once I realised there were processes, decisions, and circumstances, that affect my career and life but are actually beyond my control a lot of my anxiety vanished. We exist in a system that has inherent randomness and sometimes things just don't work out. It could be a case of wrong time, or wrong place, or both. It is easy to look at success stories and make the mistake of convoluting the results of these processes, decisions, and circumstances as a reflection of our own abilities.

2023 MEMBER SPOTLIGHTS

BENJAMIN METHA

PHD STUDENT AT THE UNIVERSITY OF MELBOURNE

MY RESEARCH

Hello, I'm Benji! I'm a final-year PhD student supervised by Michele Trenti at the University of Melbourne. My main artery of research is about maximising the amount of scientific impact that we can extract from high resolution metallicity maps of galaxies. With techniques like forward modelling and tools from geostatistics, we can use the latest data from high-redshift galaxies with JWST and local galaxies observed with programs like TYPHOON to get a better understanding of how gas flows into galaxies, how it is enriched by supernova, and how turbulence behaves to mix metals and gas together. Ultimately, the goal of my research is to find new techniques to test models of galaxy evolution from simulations, and learn more about important processes like stellar feedback.

2023 HIGHLIGHTS FOR ME

One big highlight of the year for me was my trip to Kuala Lumpur for the IAU Symposium on connecting insights from local galaxy observations to new JWST data to create a more complete picture of galaxy evolution. I gave a talk that went really well, learned a lot about the Milky Way, and made a lot of friends. I also got to try a lot of new foods, hike through a jungle, and explore a side of the world that I had never visited before.

WHY ASTRONOMY?

My first degree was in pure mathematics, but I switched to astronomy after taking an undergraduate class ran by Rachel Webster. I liked that there were so many open questions in astronomy and interesting problems to be solved. After graduation I took an internship with Michele working on a cubesat design/modelling problem, and things went from there.

IN MY SPARE TIME

Outside of astronomy I am obsessed with music. My main instrument is the piano, but I also play ukulele, accordion, bass, and harmonica. I've played in an 80s cover band, as an alt/indie duo, and in a jazz sextet. I also collect vinyls, and try to go out to see live music at least once a week.

IF I WASN'T DOING ASTRONOMY

Most likely if I wasn't in astronomy, I'd be a different kind of scientist. I've found that pretty much everything in the world is interesting if you look into it deeply enough. But if I wasn't in science I like to think I'd be a musician.

MY CELEBRITY FRIEND WOULD BE

Jack Stratton from Vulfpeck -- he is so silly and goofy and he makes such good music and has so much fun!!

BEST ADVICE I'VE BEEN GIVEN

My dad recently told me that "you should always seek to increase the variance" -- do a lot of different things, to avoid getting trapped in one of life's local minima.

GABRIELLA QUATTROPANI

PHD STUDENT AT MACQUARIE UNIVERSITY

MY RESEARCH

I'm Gabriella Quattropani, a PhD student at Macquarie University working with Matt Owers on disentangling the effects of ram pressure stripping using IFU emission line data for galaxies in cluster environments.

My research is on investigating the effects of ram pressure stripping on galaxies in cluster environments. I do this by using IFU spectroscopy from the Hector Survey and looking at the emission lines and their properties i.e. flux ratios, velocity, and velocity dispersion. At the moment I'm working on emission line fitting code to produce multi-component Gaussian fits to de-blend multiple ionising sources spatially coincident along the line of sight. We're hoping this can help us to understand how different emission line processes are affected by environments. This code will also be a part of the data processing pipeline for the Hector survey which I am simultaneously very excited and stressed about.

2023 HIGHLIGHTS FOR ME

I've had a lot of highlights this year! Work related highlights include graduating from my Masters of Research, getting into a PhD, and being hired as Graduate Teaching Associate at MQ where I do my PhD part-time and lecture/teach part-time. On a personal note, I also got engaged to my incredible partner! Though of course, the biggest highlight was being nominated as one of the best dressed at the ASTRO 3D retreat this year!

WHY ASTRONOMY?

My dad is a huge sci-fi fan so I grew up watching any sci-fi movie and TV show he could get his hands on. I think this definitely shaped my curiosity of the universe and how it worked. I was also one of those annoying kids who asked "why" a million times about everything until people just started to tell me to find out for myself, which was basically training for my PhD. I am lucky to have many encouraging people in my life who nurtured that curiosity, my parents being a huge part of that as well as my high school physics teacher from years 10-12 who I credit with reigniting my love for physics and encouraging me to pursue a career in it. The problem solving aspect is what I continue to love about astronomy, it's also great to know that there will always be unanswered questions.

IN MY SPARE TIME

Most people that know me know I am not super into outdoorsy stuff or exercise in general (terrible I know) however what a lot of people don't know is that when I was younger I was a part of a national skipping (jump rope) team and can still do many neat tricks from that. Also, I have a geographic tongue which just means my tongue looks weird and I'm super sensitive to spice.

IF I WASN'T DOING ASTRONOMY

If I hadn't chosen to do astronomy as an undergraduate then my second choice was to be an audiologist. Partly because I suffer from tinnitus and wanted to find a cure (no luck so far), but mostly because I wanted to learn sign language. Though if I had to switch at this very moment I'd likely go into data science, because I do love to code.

MY CELEBRITY FRIEND WOULD BE

Emma Watson, I really admired her growing up and she has definitely done many great things for women, I also just think she'd be super nice to hang out with.

BEST ADVICE I'VE BEEN GIVEN

Probably the best advice and the one I still struggle to implement is that "it's okay to say no." I always feel super guilty and struggle to let people know when I've just got too many things on my plate but I'm getting better!

2023 MEMBER SPOTLIGHTS

EVANS OWUSU

PHD STUDENT AT THE UNIVERSITY NEW SOUTH WALES

MY RESEARCH

I am Evans Owusu, a 3rd-year PhD student specialising in galactic archaeology, with a focus on the nucleosynthesis of low- and intermediate-mass stars under the guidance of advisors Ashley J. Ruiter, Ivo Seitenzahl, Sven Buder, and Simon Murphy. I study star DNA in the Milky Way by studying how the stars create these elements and the changes that occur over time. To do this, I use observational data from the GALAH survey and the Omega+ galactic chemical evolution code.

2023 HIGHLIGHTS FOR ME

My visit to the Max Planck Institute for Astronomy, Heidelberg, Germany, the ASTRO 3D Annual Retreat, and my participation in the 3-Minutes Thesis Challenge have been the highlights of my 2023.

WHY ASTRONOMY?

Before completing my physics degree with a geophysics major in 2013, becoming an astronomer wasn't in my plans. In the summer of 2014, the Royal Society initiated a short course in radio astronomy and instrumentation in Ghana. After learning about this, I started acquainting myself with the field. Studying, I found astronomy to be a realm of limitless mystery and beauty with potential for scientific discovery. Its collaborative approach inspired me. The words of the psalmist in Psalms 8:3 deepened my interest. Additionally, astronomy, being cross-disciplinary with mathematics, physics, and computer science, greatly interests me. Consequently, when I was admitted to the training after applying, the opportunity to study astronomy became the perfect avenue to explore the universe and share my knowledge with others.

IN MY SPARE TIME

I am a STEM consultant. I serve on the non-profit organisation as an Advisory Board Member for Empowering Female Minds in STEM (EFeMS) and one of the directors at Global Lab Network. I am also a photographer, and I love to travel, see new places, and meet people. I support Chelsea Football Club and the Black Stars of Ghana.

IF I WASN'T DOING ASTRONOMY

I would end up as a geophysicist or a geotechnical engineer.

MY CELEBRITY FRIEND WOULD BE

Nelson Mandela, for his character and fortitude of strength.

BEST ADVICE I'VE BEEN GIVEN

In your journey, there is no predetermined career path; we navigate with ideas and seize opportunities as they come. Your guiding principle should be that if a task is undertaken, it should be executed with excellence.

HYEIN YOON

POSTDOCTORAL RESEARCHER AT THE UNIVERSITY OF SYDNEY

MY RESEARCH

My research is focused on studying the neutral hydrogen gas in galaxies. Specifically, as a member of the FLASH team, I have been investigating HI 21-cm absorption lines towards galaxies with redshifts ranging from 0.4 to 1.0 using ASKAP. In our pilot surveys, we successfully detected both associated and intervening 21-cm absorbers, demonstrating their close connection to adjacent host galaxies and distant background radio sources. We anticipate uncovering more exciting results across the wide-field of the sky during the upcoming five years of the Full Survey.

2023 HIGHLIGHTS FOR ME

On the work front, it has been a very productive year for me and the FLASH team. We commenced a five-year Full Survey, released initial datasets, and started discovering new absorption features from the spectral lines. On a personal note, I had many opportunities to travel for both work and holidays this year. I finally visited and was thoroughly impressed by two Australian radio telescopes, ATCA and Parkes. Additionally, I successfully completed the Milford Track, a 53.5km hike in New Zealand, exploring the majestic Fiordland National Park. Undertaking this solo multi-night trek allowed me to fully immerse myself in the midst of the beautiful natural surroundings. Both physically and mentally, I feel that I became healthier through the preparation and experiences during these trips.

WHY ASTRONOMY?

Since childhood, I have consistently been captivated by thoughts of the cosmos, undoubtedly influenced by documentaries, science fiction movies, and animations. I engaged in small astronomy-related activities during middle and high school, and my interest deepened in my undergraduate studies, exploring various majors, including literature, physics, mathematics. These experiences led me to realise that astronomy encompasses a wide spectrum, bridging the natural science to humanities and providing a holistic view on the universe. It was then I made the decision to pursue a career as an astronomer.

IN MY SPARE TIME

I grew up and completed my PhD in Seoul, South Korea. I joined the University of Sydney as a postdoc around the time of the severe bushfire season in 2019, followed by the global pandemic. Despite the challenges, not every aspect of this period was frustrating. I transitioned from being someone distant from exercise to actively participating in various activities like pilates, swimming, running, and bushwalking. This lifestyle helps me stay healthy and successfully wrap up my time in Sydney. I am now set to embark on a new chapter, moving to another position at Seoul National University in South Korea starting December 2023.

IF I WASN'T DOING ASTRONOMY

If I were not an astronomer, my alternate career path would likely involve the travel industry or any role associated with organising international sports events such as the Olympics or the World Cup. Travelling and watching sports games have always been enjoyable for me since childhood, and I choose either of them in my free time. I used to enjoy my own imaginary journeys by watching the opening ceremonies of big sports events, particularly the parade of nations. The different teams, flags, uniforms, and the entire spectacle motivated me to imagine myself travelling many countries and experiencing diverse cultures.

MY CELEBRITY FRIEND WOULD BE

If given the choice, I would love to get to know Shohei Ohtani, the renowned baseball two-way player (pitcher and hitter) for the LA Dodgers. I enjoy watching baseball and am fascinated by its intensity, concentration, and control. Meeting people who can fully immerse themselves in their passions is always a great pleasure for me.

BEST ADVICE I'VE BEEN GIVEN

"Don't overly stress about the distant future. Instead, focus on completing very small, visible tasks that are nearby, taking one step at a time." This approach has proven effective for me and greatly helped me in finding and maintaining my own steady pace, especially during challenging times.

2023 MEMBER SPOTLIGHTS

TAYYABA ZAFAR

ASSOCIATE INVESTIGATOR AT MACQUARIE UNIVERSITY

MY RESEARCH

I am a Senior Lecturer and astrophysicist at Macquarie University, passionately exploring the interstellar realms of distant galaxies. My research focuses on the interstellar medium of distant galaxies, with a primary emphasis on studying interstellar dust and its connection with gas and metals. My work involves utilising transients and galaxies, such as gamma-ray bursts (GRBs), galaxies, quasars, and absorbers along their sightlines, to probe and understand the composition and dynamics of the interstellar medium. In the context of broader astrophysical goals, my research contributes to unveiling the mysteries of galaxy evolution and formation.

2023 HIGHLIGHTS FOR ME

Moving to a teaching department in 2023 marked a significant highlight for me, providing an opportunity to engage with students and return to the realm of teaching. This shift, following years dedicated to instrumentation work, represents a notable change, and I find immense satisfaction and joy in embracing this new professional role.

WHY ASTRONOMY?

As a child, my fascination with the vast heavens led me to count stars and delve into reading about them. Although I had a passion for math and physics, the idea of pursuing astrophysics as a career didn't initially occur to me since it wasn't taught in my hometown. I scored the highest marks in MSc Physics province-wide and was immediately hired as a lecturer. During this time, I independently started learning astrophysics, gradually deepening my understanding, fascinating me more by the vastness and beauty of the universe. Motivated by this newfound passion, I took the initiative to apply for a PhD in astronomy. I got selected after a written test and interview at the University of Copenhagen. Denmark, marked a transformative moment in my life and career. Since then, every aspect of astronomy has become a source of immense love and fulfillment for me.

IN MY SPARE TIME

A few may know that I also enjoy gastronomy. Beyond the telescopes and data analyses, I find delight in experimenting with cooking in my kitchen. It's my tasty little escape from the astronomical wonders I dive into every day.

IF I WASN'T DOING ASTRONOMY

I'd likely be deep into the world of particle physics, exploring the secrets of fermions and bosons would be my alternate universe adventure.

MY CELEBRITY FRIEND WOULD BE

If I had to choose, I would prefer not to have a celebrity friend. I find admiration in genuine connections and shared values rather than fame.

BEST ADVICE I'VE BEEN GIVEN

The most valuable advice I ever received was from my PhD supervisor, who encouraged me to always ask, assuring me that the worst response would be a simple "no." This counsel has been my source of courage, pushing me to approach people even when my instincts hesitate. It's a reminder that in seeking answers or opportunities, the act of asking is powerful, and the potential reward far outweighs the fear of rejection.

JULIA BRYANT

CHIEF INVESTIGATOR AT THE UNIVERSITY OF SYDNEY

MY RESEARCH

My passion is in studying galaxy evolution and developing new instrument technologies for astronomical instruments to take even better galaxy data. I study how galaxies have formed and evolved using the dynamics of the stars and gas measured with integral field spectroscopy. Using large galaxy surveys such as SAMI and Hector, the physics of how gas is accreted into galaxies of different types can be determined from the orientation and motions of the gas and stars. In order to get better data, I develop new astronomical instrumentation, particularly using photonic technologies. I head up the Hector instrument and Hector Galaxy Survey. Hector has just begun a 15,000 galaxy integral field spectroscopic survey of nearby galaxies on the Anglo- Australian Telescope, which will continue for 6 years. As Director of Astralis-USyd - one of 3 nodes of Australia's astronomical instrumentation capability - I am very excited about the upcoming instruments being developed for the next generation of astronomers.

2023 HIGHLIGHTS FOR ME

The Hector Galaxy Survey began. It was the culmination of more than 5 years of building the instrument and a year of commissioning. It is very exciting to now have science data being taken in earnest.

WHY ASTRONOMY?

I enjoy the puzzle solving. It is like forensics where we have limited evidence from distant galaxies and we need to put together the physics of the crime scene. In high school, I had an exceptionally inspiring science teacher in the year that Halley's Comet was visible in the evening sky. Her inspiration is part of why I am here.

IN MY SPARE TIME

I have a farm, and my escape from work stresses is to take my family to the farm, play with the animals and grow crops. I love my tractor!

IF I WASN'T DOING ASTRONOMY

I would be an archaeologist. That field has the same puzzle solving as astronomy, of piecing together the facts based on snippets of information that can be found.

MY CELEBRITY FRIEND WOULD BE

Well, I don't follow celebs, but my hubby suggested I say "Elton John because of the charity work he does and good for a party", so I'll go with that because my hubby is my real best friend.

BEST ADVICE I'VE BEEN GIVEN

"If your heart is in it, give it a go - if it doesn't work out there are very few mistakes you can't recover from. "

2023 MEMBER SPOTLIGHTS

ANDREW SULLIVAN

PHD STUDENT AT THE UNIVERSITY OF WESTERN AUSTRALIA

MY RESEARCH

I'm Andrew, I'm new here, and so far I'm enjoying the ride. My research this year has focused on analytically exploring the relationship between the structure of galaxy clusters and their observable emission properties. In particular, I studied how this relationship impacts the recovery of the halo mass, and quantified the expected variation in the associated scaling relations, for physically-motivated cluster structures. This contributes to work being done to better understand observational uncertainties in the halo mass, as motivated by the cosmological importance of the Halo Mass Function, and its ability to constrain the nature of dark matter.

2023 HIGHLIGHTS FOR ME

The highlight of the year for me was attending my first conference, the 2023 Astronomical Society of Australia (ASA) Science Meeting held at Macquarie University in Sydney. Hearing so many excellent talks, from a wide range of research areas, reminded me of why I am so passionate about astronomy. It was also a lot of fun meeting other students and researchers, hearing about their work, and making new friends.

WHY ASTRONOMY?

For me, my passion for science stems from the excitement of learning, and the quest to better understand the universe and how it works. Astronomy is at the forefront of that ambition, quite literally asking the biggest questions in the cosmos. What gets me out of bed in the morning is knowing that there is so much we don't yet know; whether its dark matter, new weird and wonderful exoplanets, the origin of time or the accelerating expansion of the universe, the fact that there are so many unresolved questions reminds me of why pursuing research in astronomy is such a promising and rewarding opportunity.

IN MY SPARE TIME

When I can, I love hiking and exploring new places. I lived in Christchurch, New Zealand, for a year in 2019 and it kickstarted my love for nature. This also doubles as a passion for photography, and I have a photowall on my PhD desk made up of some of my favourite places.

IF I WASN'T DOING ASTRONOMY

If I weren't an astronomer, I think I would definitely still have to be a scientist of some sort. In the past I was very passionate about theoretical physics, and I loved chemistry at school - maybe in another life I would be studying one of them!

MY CELEBRITY FRIEND WOULD BE

Tough one. Maybe Chris Martin, I love Coldplay.

BEST ADVICE I'VE BEEN GIVEN

"To see the world, things dangerous to come to, to see behind walls, draw closer, to find each other, and to feel. That is the purpose of life." - my favourite movie.

LUISA BUZZO

PHD STUDENT AT THE SWINBURNE INSTITUTE OF TECHNOLOGY

MY RESEARCH

Hello, I'm Luisa, I'm from Brazil and my favourite thing in the world is to travel around, getting to know new people, new places and new cultures. I study a newly discovered class of galaxies: the ultra-diffuse galaxies (UDGs) -- sources that have the luminosities of dwarfs, but the sizes of giants. The very existence of these galaxies could overthrow our whole cosmological paradigm. Thus, I'm trying to find out exactly how such galaxies were formed, evolved and survived in the Universe. I address these problems using observations from many powerful telescopes, using a combination of photometry, spectroscopy and machine learning. My work incorporates information from the globular star clusters orbiting these very faint host galaxies and the stars that populate them. This way, I am able to show that there are multiple classes of UDGs in the Universe, and these classes show inherently different properties. Some UDGs were regular dwarf galaxies in the past that were 'puffed-up' to the large sizes observed today. Other UDGs have started their lives destined to be giants but never quite reached their final stage, thus failing to become what they were supposed to be.

2023 HIGHLIGHTS FOR ME

2023 was an amazing year for me as a researcher and a big boost for my PhD. Apart from the opportunity of giving many talks and colloquia about my work in different parts of the world, I got to meet incredible people working in my field, which really reinforced my love for what I do. These experiences resulted in me getting a scholarship to go spend the year of 2024 at the European Southern Observatory in Germany expanding my research, which is quite fantastic and I'm very much looking forward to it.

WHY ASTRONOMY?

It wasn't until I was 13 years old that I had the opportunity of seeing a very clear night sky, with the Milky Way and the Magellanic Clouds, and at that moment I knew I wanted to do "something related to the sky" for my life. At that age, I had just moved with my family from the big city of Sao Paulo to a tiny countryside city at the border of Brazil and Argentina. The funniest thing is that there was absolutely nothing to do in that city (my mother and sister absolutely hated it), but I remember spending every single night with my father on the balcony staring at the sky searching for the stars and galaxies that we had spent the whole day googling. What I love most about Astronomy is that, differently from other sciences, it communicates with the society in a special way, regardless of origins, likes or dislikes, ... everyone loves to look up at the sky and to admire how immense it is.

IN MY SPARE TIME

In my undergrads, I took part in the foundation of my institute's first group of women, the Sonja Ashauer Union. We aimed to promote small talks about the importance of women in science and to analyse the history of important women in our field, as well as to provide a safe space for women in physics and astronomy where they could reach in case of any discrimination or harassment. It was deeply inspiring to see how some women, despite all resistance, were able to become such great researchers and to open doors to other talented women to do high-quality research, contributing to a more gender-balanced scientific community.

IF I WASN'T DOING ASTRONOMY

If I weren't an astronomer, I would love to be a professional volleyball player (but I don't have the skills for it, so it's great that Astronomy has been working out :D).

MY CELEBRITY FRIEND WOULD BE

I'd love to be friends with Eiichirô Oda to finally find out what is the One Piece.

BEST ADVICE I'VE BEEN GIVEN

Well, it's more of a constant reminder... but whenever I'm freaking out with my PhD (often) or worrying about my future (more often), my family always tells me to learn to enjoy myself, to take some time to appreciate how far I've come and to put things in perspective, emphasising that there's life beyond the PhD. This always put me back on track.

2023 MEMBER SPOTLIGHTS

TAÏSSA DANILOVICH

ASSOCIATE INVESTIGATOR AT MONASH UNIVERSITY

WHY ASTRONOMY?

I was fascinated by astronomy from a young age — I blame reading too many science fiction books. I also always enjoyed maths and science at school so I was pretty focused on a career in astronomy since I learned what the word "astrophysicist" meant in year 7.

IN MY SPARE TIME

I have a larger-than-necessary collection of colourful fountain pen inks and I enjoy putting different colours into my pens to use on work notes, to do lists, etc.

IF I WASN'T DOING ASTRONOMY

There is an alternate timeline in which I was more motivated to pursue a career in music. But the repetition of practice didn't suit me quite as much as the variable challenges of research and academia do. Plus, challenging as astronomy can be, I'm pretty sure it pays better than a career playing classical clarinet.

MY RESEARCH

I'm Taïssa Danilovich and I study molecules around dying stars. I study evolved stars, mostly at the low-mass end with a focus on the asymptotic giant branch (AGB). Observationally, my specialisation is in the sub-millimetre end of the radio spectrum, which I use to study molecular emission around these mass-losing stars. My analysis includes calculating mass-loss rates, and molecular and isotopic abundances. This helps us understand how these stars enrich the Galaxy and what the Sun's eventual fate will be. I usually only study a handful of stars at a time, because of the nature of my observations, which have recently come from the ALMA telescope in Chile. Despite a big difference in sample sizes, I am affiliated with the GALAH survey, because this is what my scientific goals most align with.

2023 HIGHLIGHTS FOR ME

The research-related highlight of 2023 for me was having my first *Nature Astronomy* paper accepted. (The paper wasn't published until January 2024, but the acceptance came several months earlier.) Other highlights included getting to meet a lot of the Australian community at the ASA conference in Sydney and at the ASTRO 3D retreat on Moreton Island.

MY CELEBRITY FRIEND WOULD BE

I would probably choose a writer so that we could enjoy talking about books together. Someone like Ann Leckie, Aliette de Bodard or Yoon Ha Lee.

BEST ADVICE I'VE BEEN GIVEN

Try to schedule your work time for the office and work hours as much as possible. This is trickier with international collaborations and late night meetings, but I think it's still good advice to try to keep work to the office desk as much as possible and keep a clear delineation between work time and personal time.

JESSE VAN DE SANDE

ASSOCIATE INVESTIGATOR AT THE UNIVERSITY OF NEW SOUTH WALES

MY RESEARCH

I am an Astronomer at UNSW where my research is focussed on trying to understand how our Milky Way and more massive galaxies form, evolve, and die. As Chief Investigator of GECKOS, a VLT/MUSE large program to investigate 35 nearby edge-on galaxies, most of my current research revolves around this survey. With GECKOS we aim to determine the chemical composition of stars and gas in disk galaxies, with the side-on viewpoint also giving us a chance to study vertical outflows of gas and detect faint signatures that were left behind by small galaxy mergers a long time ago. With these detailed measurements, we hope to answer the one crucial question about galaxy evolution that cannot be solved by looking at our Milky Way alone – how important are external events, like mergers with satellite galaxies, compared with the internal processes that already happen inside the galaxy?

2023 HIGHLIGHTS FOR ME

The year 2023 had many highlights for me, both personal and work-related, but one stands out. In December the GECKOS team celebrated its first internal data release (iDR1) that included fully reduced data cubes as well as a broad set of value-added data products. The data looks amazing, and our galaxies are full of complexity and nice surprises. iDR1 is a huge milestone and major achievement for the survey but would not have been possible without the effort of many people within our fantastic team. I am incredibly grateful to be leading such an amazing group of scientists.

WHY ASTRONOMY?

My love for astronomy was sparked by a science teacher when I was 16. She was an incredibly stimulating teacher and introduced me to what modern astronomy was all about. Inspired by her course, I vividly remember going out into the fields one winter night with my mother and being amazed by the Milky Way in the northern hemisphere. My first course at university was on special relativity, and learning about time dilation completely changed the way I viewed the world. However, the moment I truly knew that I wanted to pursue a career in astronomy was during an observing run to the Isaac Newton Telescope on La Palma in my 2nd year of uni.

What I love most about astronomy is the opportunity to make significant discoveries within small teams. In many areas of physics, major breakthroughs often require participation in massive collaborations, where individual contributions may be limited. However, in astronomy, vast areas of the universe remain unexplored. With access to modern telescopes, anyone can embark on a journey into uncharted territory and uncover something novel and exhilarating.

IN MY SPARE TIME

Starting in high school, and lasting for nearly eight years, I worked in a stainless-steel company as a welder and construction worker. I have always had a love for designing and building things, and this job had it all for me. It taught me so many invaluable lessons, including how to TIG weld, build anything from scratch, learn to work with people from different backgrounds and skill levels, and most importantly, diligence. I still love to build and create items for our apartment and occasionally still do some welding for a friend who restores old Italian Moto Guzzi motorcycles.

IF I WASN'T DOING ASTRONOMY

For the longest time, I wanted to be an Audio Engineer, to help produce recordings or live performances. As another side gig during high school, I worked with people in charge of the audio for concerts and performances, and I loved it. At the time, there was no Bachelor of Music and Sound Design, which would have been serious competition for astronomy. In the end, I did not like the idea of being away from home all the time, travelling around the world, and working late into the night. Isn't it ironic that I now find myself in a career that is nearly exactly that?

MY CELEBRITY FRIEND WOULD BE

Arjen Anthony Lucassen, a singer-songwriter and multi-instrumentalist who writes progressive metal space operas (be sure to check out Ayreon). Despite what most people think, metal artists are the friendliest and warmest people you will ever meet, and he is no exception. The inspiration for his music comes from astronomy and Sci-Fi, and he boasts the largest collection of space movies on Earth. I don't think I would have made it through my PhD without his music. In a gesture of gratitude, I sent him a copy of my thesis, which he loved!

BEST ADVICE I'VE BEEN GIVEN

Be kind and generous. In an ultra-competitive environment such as academia, it is tempting to be ultra-protective of your data or code, as it might give you a benefit over the people you are competing with for the next position or big grant. While helping others and sharing your data might not necessarily seem like a benefit in the short term, being kind and generous will pay off in the long term.

INDUSTRY COLLABORATION

GECKOS - A VLT/MUSE LARGE PROGRAM

Generalising Edge-on galaxies and their Chemical bimodalities, Kinematics, and Outflows out to Solar environments (GECKOS) is a large program using the Multi Unit Spectroscopic Explorer (MUSE) mounted on the Very Large Telescope (VLT).

GECKOS' aim is to capture the full range of physical mechanisms that shape the chemodynamic evolution of disk galaxies, using spatially resolved spectroscopic observations of stars and gas in 35 nearby edge-on galaxies, with a stellar mass similar to the Milky Way but otherwise spanning a wide range of physical properties such as star formation rate and morphology. The observations go out to larger radius, deeper, and with higher spatial resolution (<200 pc) than existing integral-field spectroscopic surveys. By specifically targeting edge-on galaxies, GECKOS focuses on science above the midplane to study the internal and external processes that govern galaxy evolution.

The GECKOS survey is not only a cross-node, but also internationally extended, collaboration. We are 30 ASTRO 3D members across 6 nodes. The overall team now counts 59 members, including 10 students, and 30 science projects. We are spread across 29 institutions and 13 countries. The GECKOS team encompasses members with different expertise and research interests, working from multiple perspectives to address outstanding questions of galaxy evolution.

2023 was a very collaborative year, full of achievements, for GECKOS.

In April, the core-team busy week was held at the ICRAR's UWA node and led to lots of fruitful discussions about data reduction and analysis. Throughout the year, GECKOS' team focus has been on supporting the data reduction and analysis efforts and we were thrilled to provide in December our first internal Data Release consisting of fully reduced MUSE data cubes for 11 galaxies along with their derived data products from our custom-built analysis pipeline. We also published our first GECKOS paper, as part of the proceedings of the International Astronomical Union. We were awarded 144 hours total on ALMA as well as 57 hours on MeerKAT and will soon be able to perform insightful multi-wavelength analysis of the targets.

We submitted a recent paper (Wang *et al.* 2023) that turns resolved stellar observations of the Milky Way into MUSE-like IFS observations. This will enable a direct comparison of the Milky Way to GECKOS galaxies using the same observables and analysis techniques.

Our members gave fifteen oral presentations about their GECKOS research at national and international astronomy conferences in 2023. We received support from the ADACS to optimise and fasten our own emission line fitting software, *Threadcount*. This Python package will allow us to provide high-quality emission line maps, well tuned for studying gas properties.

GECKOS future looks bright!

The next GECKOS meeting will be held in Oxford in March 2024 and aims to bring together members of the GECKOS team and the wider galaxy evolution community. The meeting will facilitate discussions on many interesting results from our amazing dataset, including unveiling hidden bars through stellar kinematics analysis, investigating radial metallicity gradients in boxy-peanut bulges, and analysing resolved galactic-scale winds to test kinematic models of such outflows.

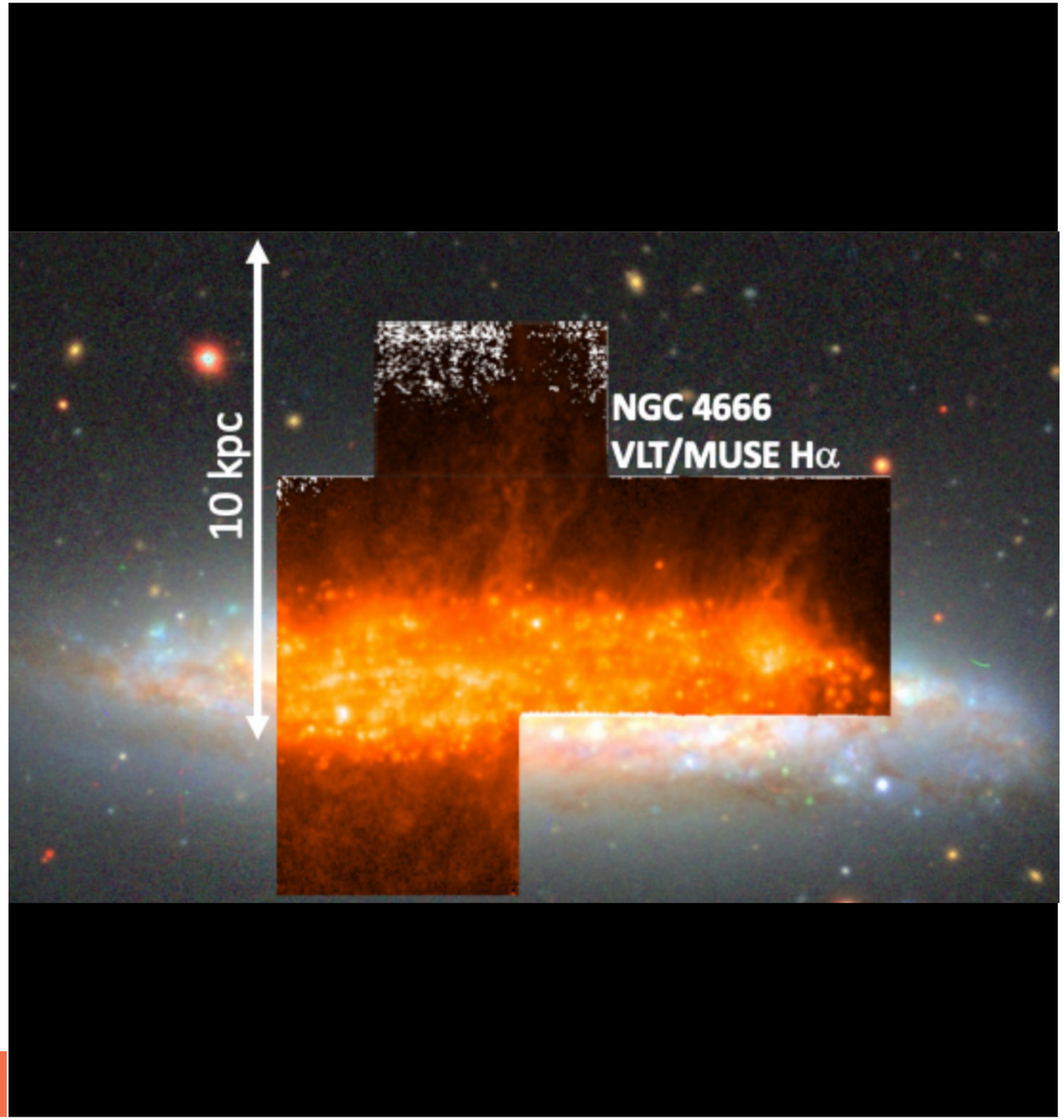


Image of ionised gas extending from the disk of starburst galaxy NGC4666. Each filament extends several kiloparsecs and is well detected in multiple emission lines with GECKOS MUSE observations.

BRINGING ASTRONOMY DOWN TO EARTH: MY SECONDMENT TO ACCESS-NRI TO MODEL STELLAR EARTH SYSTEMS

Dr Sven Buder

My venture into the realm of earth systems modelling at the Australian Earth System Simulator (ACCESS-NRI) might seem unconventional at first glance. Yet, my 4-month secondment has been a profound journey, illustrating not only the versatility of the skills that we teach astronomy students but also the potential of astronomy PhD students and Early Career Researchers to enter and significantly impact the research on climate change – but even more broadly: any data-intensive industry.

Effective Inductions for Quicker Science

One of my main projects involved developing tutorials aimed at introducing earth system modelling and high-performance computing to newcomers for either or both domains – a great on-the-fly exercise for me as a newcomer to climate science! In the long run, this task of course aims to build bridges - between scientists with theoretical expertise and research software engineers to help them put their ideas into practice. My colleagues and I designed tutorials to help students and researchers eager to contribute to climate research to understand both the overall concepts and how to start coding and comparing models as quickly as possible.

Collaboration Through Code

Astronomy and climate science, though seemingly disparate, share a common challenge—the need for sophisticated data analysis and modelling techniques. My background in stellar astronomy and teaching undergraduate students allowed me to bring a fresh perspective to ACCESS-NRI, particularly when trying to understand and explain complex connections in simple, yet effective, ways.

Learning to work with GitHub alongside my colleagues, I've experienced firsthand the power of collective and on-the-fly problem-solving and knowledge sharing, a practice that is becoming increasingly essential in the astronomical community as we tackle ever-larger datasets and more complex computational challenges.

Cultivating an Inclusive and Forward-Thinking Community

Founded less than two years ago, ACCESS-NRI thrives on an ethos reminiscent of a dynamic startup—inclusive, innovative, and constantly evolving. Engaging in spirited discussions about the institute's direction and our collective mission has been incredibly rewarding. Together, we're not just defining the future of efficient climate science; we're reimagining the very fabric of scientific collaboration and community building in world full of big data that needs to be curated and analysed efficiently by a skilled and diverse workforce.

The Future: A Convergence of Disciplines

The intersection of climate science and astronomy is fertile ground for innovation, particularly in the era of big data. The work at ACCESS-NRI is a testament to the critical need for a symbiotic relationship between domain experts in various research disciplines and skilled coders. Any of Australia's large-scale research undertakings – such as the upcoming Square Kilometre Array (SKA) project - underscores this urgency.

In collaboration with the Australian Astronomy Data and Computing Services (ADACS), ACCESS-NRI therefore aims to design workshops that not only bridge the language barriers between astronomy, climate science, and industry, but also equip researchers with the skills necessary to excel in academia or transition seamlessly into industry roles.

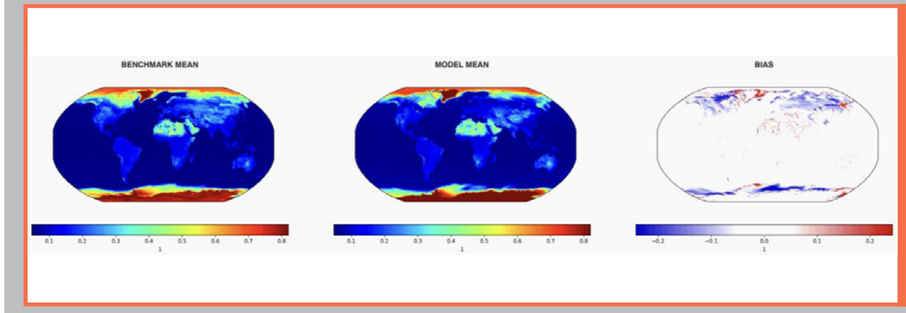


Figure: Showing the automated comparison of observations of the Earth's albedo observations as benchmark (left), one of our models (middle), and their bias (right). This could easily be a map of another planet or our Galaxy as well!

2 YEAR STUDENTSHIP AT THE EUROPEAN SOUTHERN OBSERVATORY (ESO)

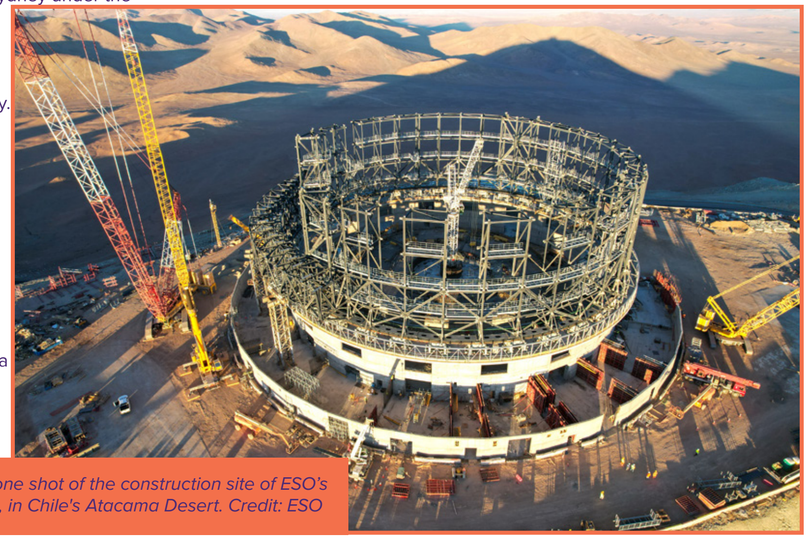
PhD student Simon Weng

Halfway through 2023, I concluded a two-year studentship at the European Southern Observatory (ESO), an integral component of my doctoral studies. Collaborating with Dr. Celine Peroux and Dr. Martin Zwaan, I delved into the study of low-density gas around galaxies, specifically in the circumgalactic medium. This project was synergistic with the research conducted at the University of Sydney under the guidance of Prof. Elaine Sadler and the team behind the ASKAP First Large Absorption Survey in HI (FLASH). The experience was invaluable, granting me the opportunity to acquire and hone techniques directly applicable to the FLASH survey.

My time at ESO proved to be exceptionally rewarding. It was a privilege to be at the intersection of engineering, instrumentation, and astronomical science for some of the world's largest telescopes, particularly during the construction phase of the Extremely Large Telescope (ELT). Among my most fulfilling roles was that of a scientific assistant to the Observing Programmes Committee, which is responsible for allocating telescope time to various research proposals. The insights gained into the criteria for a successful proposal were enlightening.

Despite the challenging cold spells of winter, my stint at ESO was thoroughly gratifying. The knowledge and skills I've gained are assets that I am eager to utilise in my forthcoming professional pursuits.

Additionally, I enthusiastically endorse this experience to fellow students and am pleased to observe a growing number of ASTRO 3D students embarking on this journey.



This image, taken in late June 2023, shows a drone shot of the construction site of ESO's Extremely Large Telescope at Cerro Armazones, in Chile's Atacama Desert. Credit: ESO

MENTORING PROGRAM 2023

In mid-2023, ASTRO 3D helped organise the new ARC Centre of Excellence Mentoring Program through Mentorloop.

Twelve* Australian Research Council Centres of Excellence were part of this inaugural program. It was launched on 7 June 2023 by ARC Deputy CEO Dr Richard Johnson and Georgia Pascoe, Head of Customer Success (APAC) for Mentorloop.

This program is a unique opportunity for researchers to start a mentoring relationship with other researchers and industry professionals. Participants can connect to people from within ASTRO 3D or one of the other Centres of Excellence listed below or invited industry partners, gaining insight, advice, and access to opportunities that help manage and progress their careers.

Five ASTRO 3D mentors, eight mentees and three researchers who opted to do both signed up for the program in June. Five members reached the Growing Together milestone (complete and expand on goals together), and seven had their first meeting.

The ARC Centre of Excellence Mentoring Program will continue into 2024 where ASTRO 3D members will be invited to participate.

*ARC Centre of Excellence Mentoring Program participating Centres:

ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions

ARC Centre of Excellence for Automated Decision-Making and Society

ARC Centre of Excellence for Children and Families over the Life Course

ARC Centre of Excellence for Dark Matter Particle Physics

ARC Centre of Excellence for the Digital Child

ARC Centre of Excellence for Engineered Quantum Systems

ARC Centre of Excellence for Future Low-Energy Electronics Technologies

ARC Centre of Excellence for Gravitational Wave Discovery

ARC Centre of Excellence for Innovations in Peptide and Protein Science

ARC Centre of Excellence for Plant Success in Nature and Agriculture

ARC Centre of Excellence in Synthetic Biology

ARC Centre of Excellence for Transformative Meta-Optical Systems

MAXIMISING YOUR MENTORING EXPERIENCE FOR CAREER ADVANCEMENT

On October 18th, CI Darren Croton organised an online seminar titled 'Maximising Your Mentoring Experience for Career Advancement' to advocate for Mentorloop and mentoring within the Centre, catering jointly to both the ASTRO 3D and Dark Matter Centre of Excellence communities.

The seminar offered comprehensive insights into mentoring, covering topics such as preparation, expectations, and practical tips, followed by a panel discussion featuring seasoned mentors. Attendees had the opportunity to ask questions and engage in discussions, and the session was recorded for mentors and mentees to reference in the future.

SPEED MENTORING

Subsequently, on October 26th, ASTRO 3D and the Dark Matter Centre once more joined forces to run an online speed mentoring event using the Twine platform. This event provided mentees with swift access to career advice from a varied group of mentors.

Over the course of the hour-long session, 18 participants engaged in rapid 4-minute discussions, yielding a total of 56 connections and 224 minutes of insightful dialogue.

The fast-paced nature of the event created an energetic atmosphere, making it an engaging and effective networking opportunity for all involved.

TRAINING, WORKSHOPS AND CONFERENCES

Participants of the ANU Writing Workshop enjoyed a group dinner on the workshop's final night.

ANU WRITING WORKSHOP

3-6 April 2023, ANU main campus, Canberra

Fourteen ANU ASTRO 3D members participated in a local writing retreat. This workshop provided a dedicated opportunity for members to focus on writing an academic paper in the supportive company of peers. The group had dinner together on the final night.

Quote: *It was great to get out of our offices and concentrate on writing!*

AUSTRALIAN PUBLIC SERVICE (APS) SHOWCASE

24 May 2023, Virtual

In late 2022, ASTRO 3D Advisory Board members expressed interest in exploring potential pathways for scientists transitioning from Centres of Excellence to STEM-related roles within APS agencies. They proposed piloting a program aimed at raising awareness of these pathways within ASTRO 3D, which was midway through its term. The goal was to raise awareness of APS career opportunities, particularly in IT, data analysis, and data science, and to establish pathways for individuals to pursue suitable roles.

Six months later, a one-hour webinar was held, drawing forty-six ASTRO 3D members, predominantly comprised of students and early career researchers (ECRs), eager to learn about potential career prospects within APS agencies. Representatives from the Bureau of Meteorology, Geoscience Australia, IP Australia, and the National Measurement Institute delivered presentations outlining their respective areas of work, desired skill sets, and the types of roles that might appeal to ASTRO 3D researchers.

The showcase was so successful that the concept has been pitched to the APS Commission to consider managing as an ongoing pathway program for scientists intersted in transitioning to roles in the APS.

CAREER AND PROFESSIONAL DEVELOPMENT FOR WOMEN LEADERS

In 2023 we curated and ran a bespoke professional development and career enrichment program facilitated by Nicole McKenna. The program was open to all level C-E members who identify as women. The purpose was to support a cohort of women to strengthen their research leadership network in Astrophysics, and to develop plans for future ARC CoEs and collaborative efforts in Astrophysics across Australia. The year-long program spoke to the core of ASTRO 3D's gender equity goals. The aim was to provide a legacy to the community, and foster and carry these efforts and networks beyond 2024.

The year-long program included five one-on-one career coaching sessions with Nicole and a 3-day event in Sydney. Guest speakers at the 3-day event included Australia's Chief Scientist Cathy Foley and CSIRO's Elanor Huntington. Among many highlights were interrogating our values and strengths and learning to apply the 'de Bono' hats to critiquing research proposals. The program was incredibly well received, with 92% of participants rating the event as 'better or much better than expected', and 100% of the participants rated one-on-one coaching and professional support sessions provided by Nicole McKenna as 'very or extremely useful'.

OUTFLOWS – 'NEW VIEWS ON FEEDBACK AND THE BARYON CYCLE' CONFERENCE

17-21 July 2023 Healesville, Victoria

CI A/Prof Deanne Fisher and ASTRO 3D Postdoc Dr Rebecca Davies brought together a community of around 80 local and international experts in radio, UV, optical and simulations studying the diffuse gas around galaxies and the feedback mechanisms within galaxies that drive the gas flows. The conference highlighted new results on feedback, accretion and the CGM enabled by pioneering new imaging techniques using JWST, ALMA & MUSE/KCWI image slicers and compared these results to the findings of large absorption line studies that have driven the past decades of insights on the baryon cycle. There was a very positive response from attendees.

GALAXY TRANSFORMATION ACROSS SPACE AND TIME CONFERENCE

11-15 September 2023, Shine Dome, Canberra

ASTRO 3D co-sponsored the conference with ESO, ANU and UWA. The meeting brought together simulations, radio and optical observations. We were proud to host many international visitors and a handful of guests from the Department of Industry, Science, and Resources. The meeting showcased results from the Australian-led ESO large programs MAGPI, GECKOS, and MAUVE. Exciting results were highlighted from new facilities, including JWST, Meerkat, and ASKAP.

Image. (main) ASTRO 3D participants for the Career and Professional Development for Women Leaders. (Inset) Program's guest panellist (from left) Wendy McCarthy AO, Mary Foley AM and Cathy Foley AO, delighted and informed us by generously sharing their stories. We learned that it was all about relationships and that building and nourishing relationships had been the cornerstone of their careers.

ASTRO 3D X AGATE (ANALYSIS OF GALAXIES AT THE EXTREMES) PREPARING FOR THE UPCOMING DEEP, WIDE GALAXY SURVEYS WORKSHOP

31 October – 2 November 2023, Kooyong Lawn Tennis Club, Melbourne

This workshop touched on subjects such as ultra-diffuse galaxies, HI-rich dark galaxies, globular cluster and dwarf galaxy simulations, and the processes involved in transforming globular clusters into small galaxies (and vice-versa). Also discussed was the upcoming LSST, its potential to study the low-surface brightness universe, and much more. The workshop had good attendance from several ASTRO 3D nodes and projects /surveys (including the newly joined AGATE group), with many cross-node collaborations and interesting science prospects arising from the discussions, especially in the field of low-surface brightness science.

MATE & ASTRO 3D

INSTEM CONFERENCE 2023

19-21 September, Naarm/Melbourne

After a successful pilot event last year, the 2023 InSTEM conference was hosted by RMIT Melbourne and coordinated by STEM-focused Centres of Excellence. InSTEM is a hybrid event designed to be a networking and career development conference for people from marginalised or underrepresented STEM groups and their allies.

The event organisers worked hard to create a safe space for people to meet, make connections, build relationships and learn from lived experiences and experts. It demonstrated best practices in event organisation and had a fantastic program of keynotes, invited talks, panel discussions and workshops. There were also extended breaks to allow for networking and discussions. It was heartening to listen to these talks and see that ASTRO 3D has made excellent progress on many of the issues they spoke about, and it is always great to find more ways of improving.

'I listened to excellent talks on imposter syndrome and burnout (and what you can do about them) and science communication. There were panel discussions on neurodiversity (very helpful as we will have a similar topic at the Retreat) and using privilege and power to improve diversity, equity and inclusion in organisations. I also enjoyed many interesting discussions with other COOs, researchers, and students from ASTRO 3D and other centres. I came away from the conference with at least three things I can implement immediately and lots to research and think about.' (Ingrid McCarthy)

ACTIVE BYSTANDER TRAINING

15 November 2023, Virtual

Active Bystander Training is designed to empower individuals with the knowledge and tools to effectively intervene in situations involving inappropriate behaviour. The training equips individuals to make a positive difference and promote a culture of respect and inclusion.

The ASTRO 3D Equity, Diversity, and Inclusion (EDI) Committee wanted to assist ASTRO 3D members in contributing to a safe and respectful workplace. In November, Motivating Action Through Empowerment (MATE) from Griffith University ran an interactive 90-minute webinar that was well-attended and well-received by participants. It was a very practical session and provided tips on ways to say something or step in when members witness uncomfortable or inappropriate behaviours.

STUDENT WORKSHOPS

29/30 May 2023, Science Meeting, Fremantle, WA

- A whole-day workshop on transitioning to industry, how to teach astronomy concepts to undergraduate students, science communication, leadership, and machine learning. Students were also provided with the opportunity to have a peer review of their writing.

- *Presenting your Science* training facilitated by Science in Public.

27 November 2023, Annual Retreat, Tangalooma, Qld

Cruxes Innovations - *Exploring and Preparing for Post-Centre Career Options Workshop.*

ECR/MCR WORKSHOPS

30 May 2023, Science Meeting, Fremantle, WA

Cruxes Innovations - *Exploring and Preparing for Post-Centre Career Options Workshop.*

27 November 2023, Annual Retreat, Tangalooma, Qld

5R Leadership Program - *Leadership as Social Identity Management.*

EDUCATION AND OUTREACH

SCIENTISTS TAKING ASTRONOMY TO REGIONAL SCHOOLS (STARS) (COMPLETED)

The STARS program engaged primary and secondary school students in rural, regional and remote locations through a series of visits by research scientists and PhD students in astronomy and astrophysics. Between February 2020 and April 2023 (allowing for numerous COVID interruptions), STARS was supported by a $85,000 grant from the Federal Government.

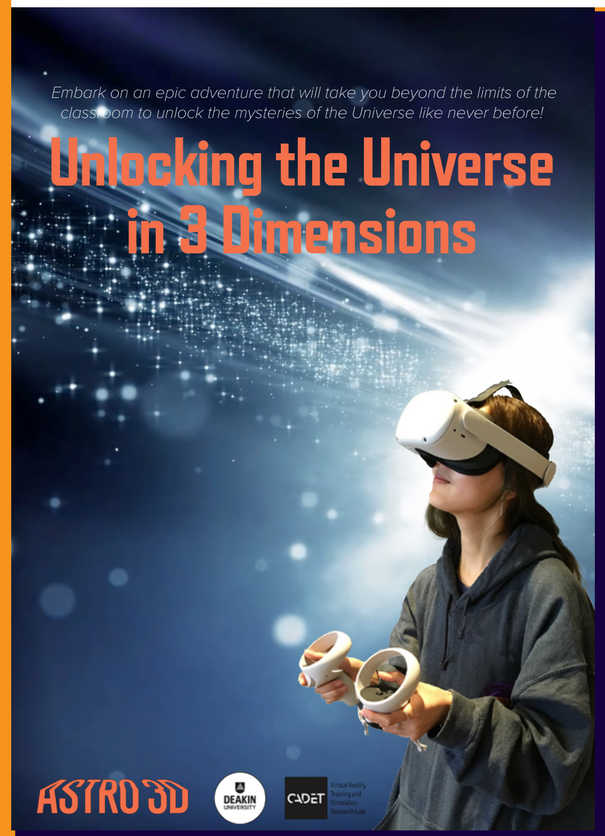
Through this program, ASTRO 3D reached close to 6,000 participants (students, teachers and community members), delivering forty-three 8” Dobsonian telescopes to forty-three schools in all states and territories (except the NT). We supported teachers and students by providing a range of technical information, curriculum resources, student project ideas and ‘how to’ videos. These are all available on the ASTRO 3D website.

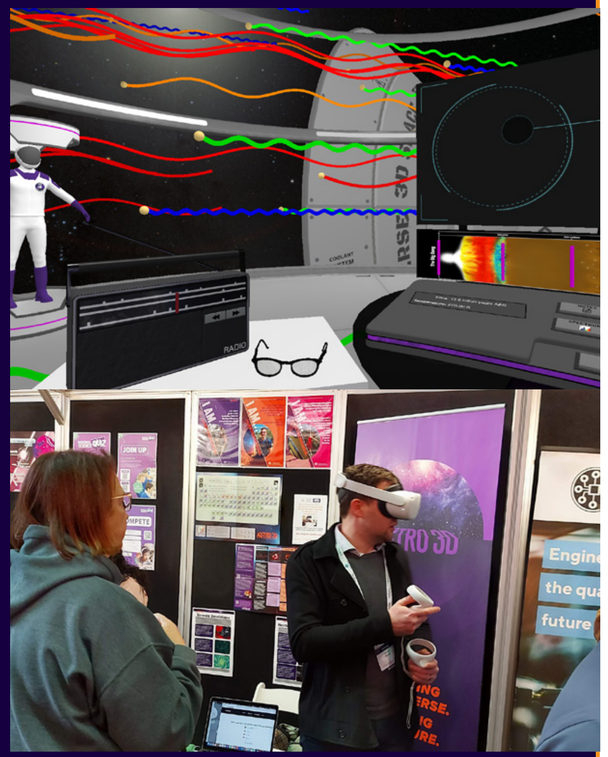
Feedback from participants on the program was extremely positive. The Federal Government approved the final report on STARS in July 2023.

SCIENTISTS TAKING ASTRONOMY TO REGIONAL SCHOOLS WITH MUSIC AND PHYSICS (STARSMAP)

An ANU proposal (led by Education and Outreach Affiliate Dr Brad Tucker) for another federal grant was awarded ($100,000) in February 2023. ASTRO 3D is a partner in this proposal. It is an extension of the STARS project but will include ANU's Music and Physics faculties and visit twenty-five schools over two years.

Only one visit to an Indigenous youth program in remote NSW and to schools in Yeppoon in regional Qld was carried out in 2023. Other planned school visits had to be postponed due to clashes with different events and the unavailability of academics.





VIRTUAL REALITY EDUCATION MODULE – UNLOCKING THE UNIVERSE IN 3D

The ASTRO 3D Virtual Reality (VR) education program is an innovative, immersive program that aims to increase student engagement in and understanding of the complex astronomical science of the origin of the Universe. It highlights the parts of ASTRO 3D research that address critical portions of the Year 10 Australian Curriculum for Science.

The VR program is currently under development through collaboration with the Deakin University Virtual Reality Laboratory. Despite the project running over, the program’s quality – its level of detail, interactivity and user experience – is of a very high standard.

All four modules are in the final stages of development. The expected completion date is April 2024. The teaching and learning resources to accompany the VR program will be completed to coincide with the program’s completion.

The program was promoted at the 2023 National Science Teacher Conference (CONASTA), where there was significant interest from teachers and other education professionals. In April, the Deakin team had a booth at the dedicated VR conference ‘Laval Virtual 2023’ in France, where they profiled the ASTRO 3D VR.

Images: Top left, Flyer made to promote and profile the ASTRO 3D VR at the dedicated VR conference 'Laval Virtual 2023' in France. Top right, Inside the VR program - users observe radio waves coming from space. They use the radio to ‘tune into’ the radio wave emitted from a hydrogen atom at 21 cm during the Epoch of Reionisation. Bottom right, STEM Program and Policy Officer from the Federal Education Department testing the VR at CONASTA 2023

2023 Initiative:

To further support teachers in the schools that had received a telescope as part of the STARS program, a 4-part series of online teacher professional learning was organised and ran between September and November 2023. These sessions included a refresher on setting up the telescope, using telescope accessories, and finding globular clusters. Each session was recorded and is available on the ASTRO 3D YouTube channel

WORK EXPERIENCE PROGRAM @ SWINBURNE

ASTRO 3D Education and Outreach Officer at Swinburne University, Krystal De Napoli, coordinates the multiple, week-long work experience programs in partnership with the Centre for Astrophysics and Supercomputing (CAS). Students explore research interests by undertaking a small astronomical project under the supervision of a professional astronomer, attending presentations/scientific talks by ASTRO 3D astronomers, and learning how to align future school studies with potential career aspirations. While most students come from Melbourne, a significant proportion come from rural and regional Victoria and interstate.

In 2022, seven programs were conducted with forty students participating. In early 2023, Krystal spent considerable time and effort recruiting researchers from ASTRO 3D and CAS as supervisors. She was so successful that in 2023, fifteen programs were run across the year, with 103 students attending.

CENTRE OF EXCELLENCE OPERATIONS FORUM

Melbourne Connect, 2 February 2023

Operational staff from the various Centres of Excellence met to share best practices across the various operations portfolios. It’s always great to connect with peers and glean good ideas for improving things. There were presentations on Starting, Building, Evaluating and Legacy’, communications, education and outreach, team dynamics, government relations and the structure of centres. Specific groups (finance, COOs, node admins, E&O, media and comms, and stakeholders and engagement) met in breakout sessions to discuss their respective roles and plans for 2023.

An Outreach and Engagement Expo allowed each centre to have a physical space to share their outreach activities/demos, schools’ activities, merchandise, publications, flyers, digital materials, banners, etc.

LEGACY

A discussion on the legacy of CoE education resources when Centres finish was initiated at the Centres of Excellence Operations Forum in Melbourne in February 2023. ASTRO 3D spearheaded the research into the best repositories for our education/outreach materials. It was determined that Scootle, the national digital learning repository operated by Education Services Australia (ESA) (owned by the state, territory and Australian Government education ministers) was the most appropriate. ESA are very pleased to host the resources.

TRANSLATING ASTRO 3D RESEARCH INTO A POSTER FOR SCHOOLS

Original research by ASTRO 3D members Prof. Chiaki Kobayashi, A/Prof. Amanda Karakas and Dr Maria Lugaro on the origin of the elements was turned into a poster for the classroom. One thousand posters were printed in June 2023 and were so popular that all were distributed by November. Another print run is planned for early 2024.

CONFERENCE OF THE AUSTRALIAN SCIENCE TEACHERS ASSOCIATION (CONASTA), ADELAIDE

ASTRO 3D had an exhibition booth with three other Centres of Excellence – Oz Grav, Dark Matter and FLEET. We showcased our new periodic tables for distribution, demonstrated the VR and discussed all our E&O programs and activities with over 300 science teachers from schools across Australia.

ASTRO 3D PHYSICS DEPTH STUDY

NSW Year 12 students must complete a Depth Study involving 15 hours of proven investigative study that allows the further development of one or more concepts found in the senior science curriculum. In astronomy, students must demonstrate a deep understanding of the nature of light and spectroscopy and achieve specific outcomes for the final assessment. Part of the study must include contact with professionals in their workplace environment.

ASTRO 3D continues to run an annual Depth Study at Siding Spring Observatory (SSO) NSW for Year 12 students. This takes place in May each year. Matt Dodds, physics teacher and ASTRO 3D E&O Affiliate, coordinates and runs the program for 50 students and teachers. The program included presentations from four ASTRO 3D researchers, inquiry-based activities to develop understanding, tours of the SSO telescopes, solar observation and evening star-gazing.

E&O TRAINING FOR ASTRO 3D RESEARCHERS

Science communications company, *Scientell* hosted a day long science communications training program for the Sydney nodes' ASTRO 3 D members. Seven researchers participated.

OUTREACH ON THE P&O CRUISE TO EXMOUTH (WA) FOR THE TOTAL SOLAR ECLIPSE

Krystal De Napoli gave two talks on Indigenous astronomy and spoke on two panels about astronomy with other astronomers and astrophotographers from across Australia, alongside members of the Dark Matter and OzGrav centres. She was able to discuss accessing astronomy education and ways for high school students to get involved in astrophysics.

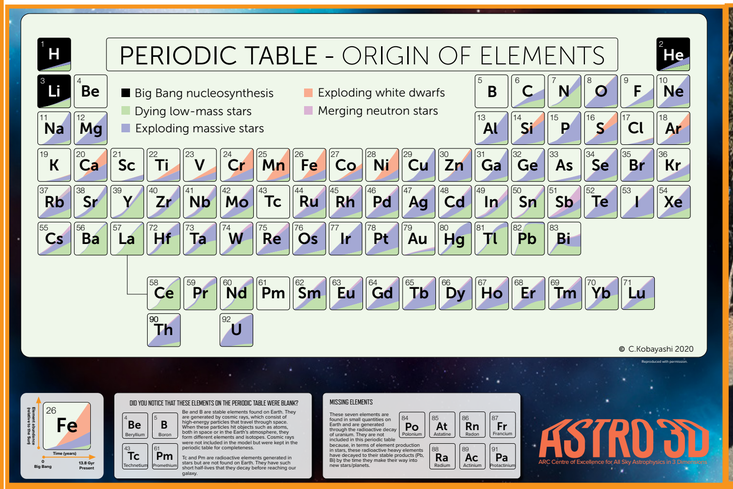
ROAD TRIP TO REMOTE SCHOOLS IN WA

During May the outreach team at ICRAR completed a two-week regional tour of the Kimberley and Pilbara, north of WA. This tour was made possible thanks to the very kind funding from ASTRO 3D, allowing us to visit these remote areas and make such a great impact on those living in these regions.

We made the most of every possible minute on the tour to ensure we could reach as far and wide across these communities. We visited schools in Tom Price, Broome, One Arm Point, Derby, Fitzroy Crossing, Port Hedland, Roebourne and Karratha. Across the fifteen days we visited 10 schools, travelled 3,878 km (just greater than the distance of driving from Perth to Canberra!), delivered 37 programs and engaged over 750 students. My highlight was being able to reach the remote community of One Arm Point and spend the day talking about all things space with the students and teachers alike.

It was certainly a team effort. I was joined on the tour by ASTRO 3D extraordinaires Kate Harborne, Amelia Fraser-McKelvie and Ravi Jaiswar. But the collaboration on the tour extended beyond ICRAR, as we were also joined by Aspire UWA, CSIRO and ECU. We could not have achieved such a wide impact though without the assistance of Aspire UWA, who helped connect us to the many schools we visited.

ASTRO 3D researchers participated in these tours taking telescopes and ASTRO 3D activities.



Images: (Left to right) Periodic Table - Origin of Elements Poster, Year 12 students at the 2023 Depth Study at SSO holding the Hertzsprung Russell poster they built. Dr Kate Harborne with school students on the Kimberley/ Pilbara tour.

NATIONAL SCIENCE WEEK AUGUST

ACT – ‘Science in the Centres’

Delese Brewster and Lara Sharp coordinated ASTRO 3D ‘booths’ at two shopping centres/malls as part of the ACT NScWk Coordinating Committee’s program. We highlighted all of ASTRO 3D’s E&O resources and had ASTRO 3D researchers available to interact with the public.

Participation in ACT’s Uncharted Territory Festival – STARS 3D

In an extension of the U4D dance/science collaboration in 2019, ASTRO 3D supported the Chameleon Collective (a community dance group living with disability) with 3D simulations as a backdrop to a dance program celebrating the Universe from chromosomes to mapping the galaxy.

Footy Oval Astronomy

Telescopes on Gembrook Oval in Melbourne. This event was broadcast live to Channel 31 and PhD students Zara Osborn (Monash) and Antonia Fernandez (Swinburne) gave a short interview on their research.

Sidewalk Astronomy in Perth – telescopes in Kings Park and South Perth Foreshore.

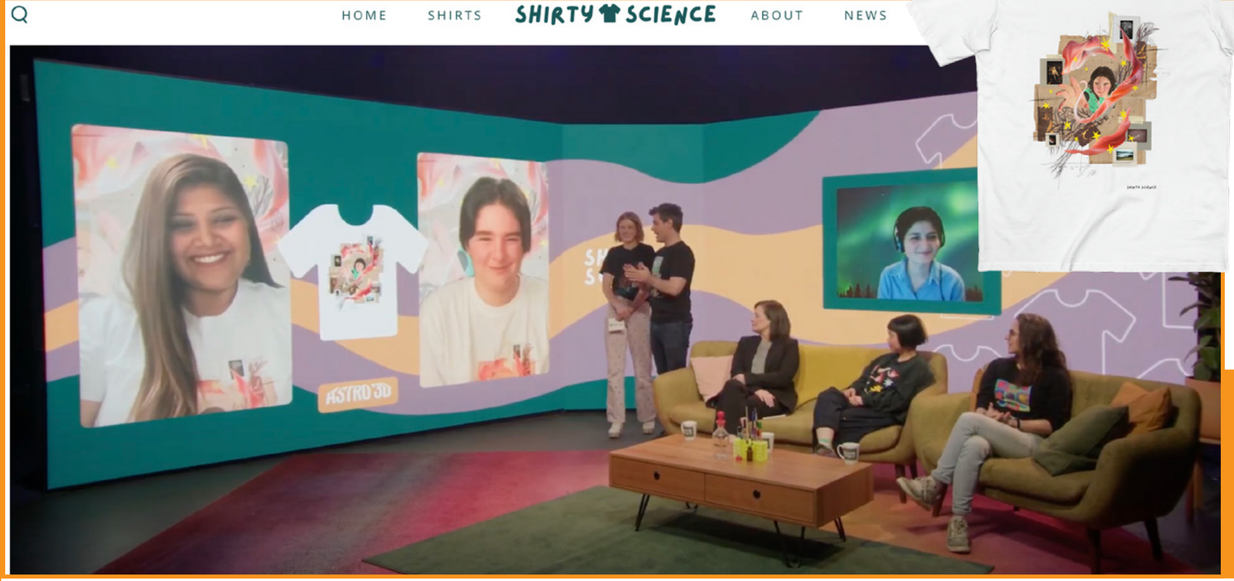
ASTRO 3D activities at a community centre Festival.

ASTROFEST PERTH

The public was engaged with ASTRO 3D E&O activities including the Epoch of Bubbles, the CMB Game and the pocket Solar System.

‘SHIRTY SCIENCE’

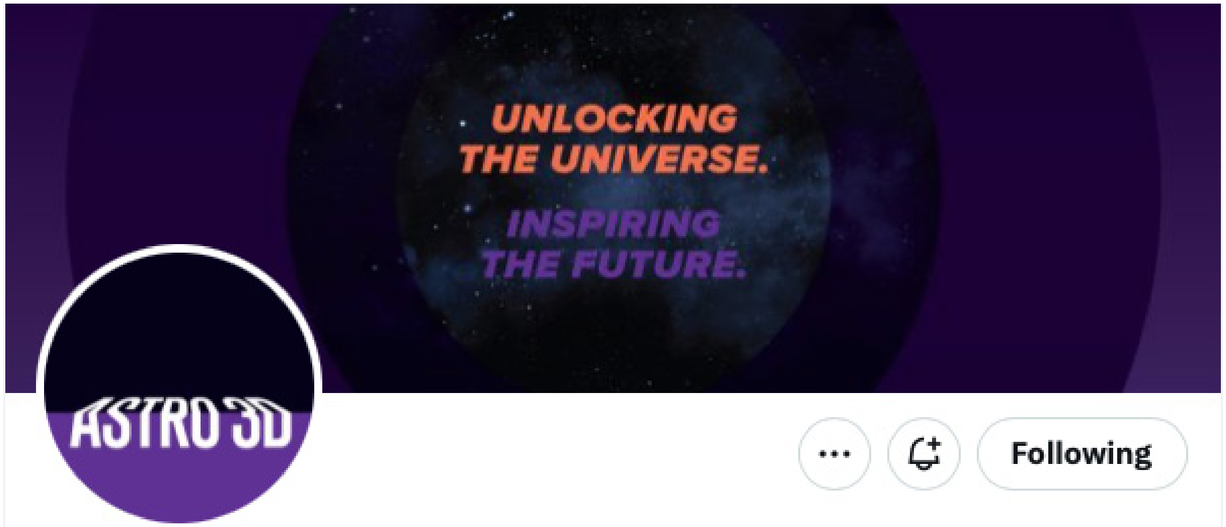
Postdoc Aditi Vijayan from ANU was partnered with Nungheena Gowland, a talented artist and STEM enthusiast from ACT to create a cosmic t-shirt as part of Shirty Science, a National Science Week initiative with four other Centres of Excellence. Aditi and Nungheena’s design won ‘The Most Excellent Science Shirt’



MACQUARIE UNIVERSITY ASTRONOMY OPEN NIGHT

At the open night, Delese Brewster and Lara Sharp ran a dedicated space with multiple informative and hands-on activities including a to-scale Universe timeline, a scale model of our solar system, spectroscopy explained, the Epoch of Bubbles and the Origin of Elements. They were assisted by ASTRO 3D researchers from Macquarie.

Images: (Clockwise from top left) Delese Brewster and Sven Buder with members of the public at the ASTRO 3D booth in a local shopping centre, Footy Oval Astronomy in Melbourne, Macquarie University Astronomy Open night and the announcement of Shirty Science winner AI Dr Aditi Vijayan. (Inset: Aditi and artist Nungheena Gowland with their winning design)



SOCIAL MEDIA

ASTRO 3D is active on Facebook (678 Followers) and Twitter (1,471 Followers), to a lesser extent LinkedIn (400 Followers) and Instagram (368 Followers) and has a dedicated YouTube channel (567 Subscribers). Through these platforms we engage ASTRO 3D researchers and University partners, the broader astronomy research community, key stakeholders, and the general public. We also target the education sector through science teacher Facebook groups and mailing lists.

Specifically, we:

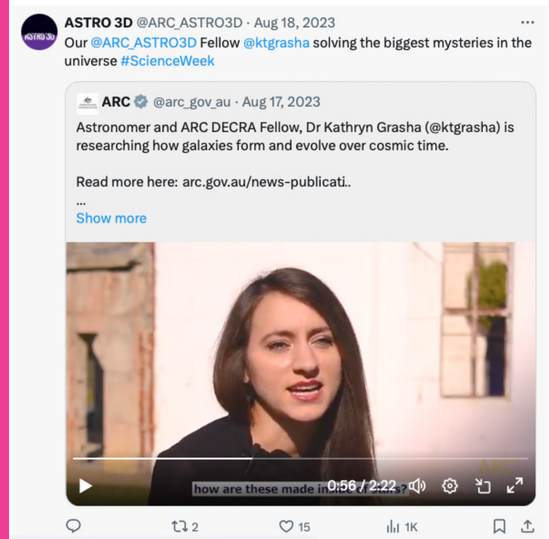
- Provide new relevant ASTRO 3D content (including media releases) across all platforms;
- Share partner social media and online content;
- Engage in conversations with the science community and general public; and
- Share video content on YouTube and Instagram.

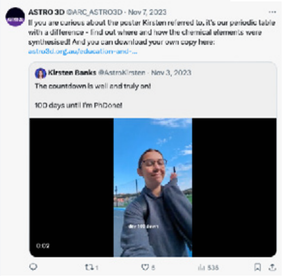
To increase engagement on Facebook and Instagram, several campaigns were conducted in 2023. Informative posts and video vox-pops leveraged off events such as the Astronomical Society of Australia's Annual Meeting (3 Jul – 7 Jul 2023) and ASTRO 3D's Science Meeting (27 Jun – 9 Aug 2023). Similarly, campaigns were run to align with National Science Week (13 – 18 Aug 2023) and our involvement with Shirty Science. These involved photos, invitations to be involved and quizzes.

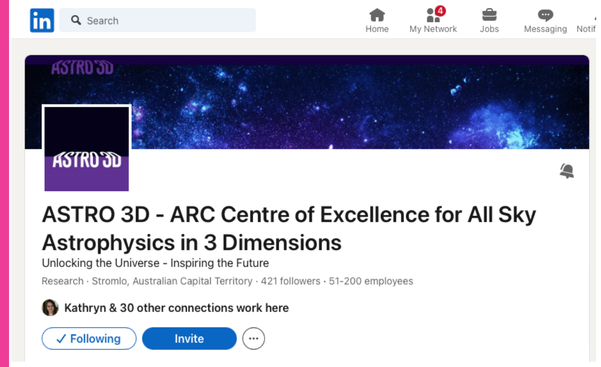
These more creative campaigns increased the engagement across the platforms.

Topic	Dates	# of Post Engagements
Astronomy Word Wednesday	2 Nov – 22 Dec 2022	90
	4 Jan – 1 March 2023	
Vox-pops with ASTRO 3D scientists	27 Jun – 9 Aug 2023	138
ASA's annual meeting	3 – 7 Jul 2023	Hundreds
National Science Week – mystery photos	13 – 18 Aug 2023	345

Over 2023, over 12,500 Facebook accounts were reached (an increase of 200%) with 1,500 post engagements (an increase of 30%). Over 500 Facebook users clicked on an ASTRO 3D post (an increase of 122%). There were 758 impressions on LinkedIn. The number of LinkedIn followers increased by more than 250% in 2023. The most popular post on social media in 2023 was the ASTRO 3D-led paper on the JWST (7 Nov 2023) with 746 post engagements.







ASTRO 3D SCIENCE MEETING

ESPLANADE HOTEL, FREMANTLE, 30 MAY - 2 JUNE 2023

A very successful Science Meeting was held, with 110 members attending in person. An additional nine members joined the meeting online. Students and ECRs benefited from training in presenting science to different audiences, building their profiles using social media and exploring careers outside of academia.

There were inspiring and insightful science updates from project leads and many research updates, especially from the students and ECRs. Our culture of collaboration was showcased by plans to work together to produce pipelines for ESO large programs, MAUVE and GECKOS. Each talk was recorded and is available for viewing on the ASTRO 3D YouTube channel.

A highlight of the meeting was the 'Meet the Press' panel discussion and Q&A facilitated and moderated by Science in Public. Four local journalists from television, newspaper/online and radio spoke about how the media works, what they are looking for in a story, what makes astronomy 'news', and how to ensure research is reported accurately. A lively Q&A session ensued.

The ASTRO 3D community voted for their favourite talks in various categories. The following talks were awarded with a trophy:

Best overall presentation: Amelia Fraser-McKelvie (UWA)

Best student presentation: Andrei Ristea (UWA)

Best sparkler: Monse Martinez (Swinburne)

Most scientifically creative presentation: Ben Mentha (Uni Melb)

Most scientifically energetic presentation: Daniel Zucker (Macquarie)

Most expressive presentation: Madi McKenzie (ANU)

ASTRO 3D ANNUAL RETREAT

TANGALOOMA RESORT, QLD 27 NOVEMBER – 1 DECEMBER 2023

This was ASTRO 3D's last Annual Retreat, and it was amazing to celebrate this milestone on a tropical island with 120 ASTRO 3D members from across all nodes.

The packed program kicked off on Monday with student and ECR workshops on applying for positions outside academia (provided by Cruxes Innovation) and Leadership as Social Identity Management (delivered by 5R Leadership).

The main program began on Tuesday with sharp and snappy Project Sparklers delivered by the project leads who provided highlights from the last six months. The members then split into their project groups to discuss planning for the Centre's last 12 months. The various committees (student, ECR, MCR and EDI) met for discussions on future plans.

The Wednesday morning was taken up with group discussions on ASTRO 3D's legacy and then reporting back to the wider Centre on the outcomes of those discussions. Our Advisory Board was kept busy meeting with the Management Committee, CIs, senior researchers and professional staff.

In the afternoon, the Untapped Group led a diversity awareness training session. This was followed by a panel discussion with three ASTRO 3D members who shared their personal experiences with neurodiversity, which was very powerful.

The Education and Outreach team coordinated a very popular E&O Challenge on Thursday morning, where members were put into teams and rotated through a series of activities that promoted collaboration, teamwork and problem-solving. These skills are vital to being a successful researcher. Demonstrating astronomical and other scientific concepts by engaging with school students and the general public via outreach activities can further develop and enhance these skills. The favourite activity was '3D your science' in playdough!

Other highlights included:

- Conference awards dinner with a Tropical Beach Party theme. Remarkably, 67 members were nominated across seven categories, which is a testament to how people are valued and respected for their community efforts in ASTRO 3D.
- The ultimate trivia night led by departing COO, Ingrid McCarthy.
- Wild Dolphin feeding

ASTRO 3D 2023 ANNUAL AWARDS

(Clockwise from top left)

Kim Dorrell - *Most Supportive Centre or Node Administrator*

Jesse Van de Sande - *Creating Centre Collaboration Opportunities*

Ingrid McCarthy - *Encouraging Centre Community, Culture and Cohesion*

Kate Harborne - *Supporting Education and Outreach Activities*

Sarah Martell - *STAR Award for the Centre Member who most embodies ASTRO 3D Values*

Tayyaba Zafar - *Promoting Equity, Diversity and Inclusion*

Amanda Karakas - *Supporting Centre Students and Early Career Researchers*

PHD COMPLETIONS

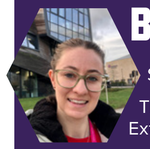
KARIUKI CHEGE

Curtin University

Thesis title: Calibration and Data Analysis Strategies for Enhanced 21-cm EoR Limits with the MWA

Supervisors: Dr Chris Jordan, Dr Christene Lynch, Prof Cathryn Trott

Kariuki has commenced a post-doc position at University of Groningen, and is working on LOFAR EoR data analysis.



BRONWYN REICHARDT CHU

Swinburne University of Technology

Thesis title: Outflows and the Circumgalactic Medium in Extremely Gas Rich, Turbulent Disk Galaxies

Supervisors: Deanne Fisher, Glenn Kacprzak

Bronwyn Reichardt Chu has moved to the other side of the world to start a postdoctoral position at Durham University in the UK, working with Dr Anna McLeod. She will be moving to galaxies even more local than the DUVET sample to study what happens before the supernovae explode in starforming galaxies at about 10-parsec resolution, using IFU data. Pre-supernovae feedback from young massive stars regulates the density of the interstellar medium that the supernovae then explode into. This affects the impact that supernovae will have on a region of a galaxy, contributing to how stellar feedback regulates star formation. Bron is excited to start working on this project, which follows on well from her PhD topic of galaxy-scale winds driven by stellar feedback. Bron is also getting used to the colder weather in Durham, and hoping that there's a chance of snow at Christmas!

JEN HARDWICK

University of Western Australia

Thesis title: Angular momentum and atomic gas: Their connection in the local Universe in observations and simulations

Supervisors: Luca Cortese, Danail Obreschkow

DR PIA JAKOBUS

Monash University

Thesis title: Equation of State effects in Core-Collapse Supernovae

Supervisors: Alexander Heger and Bernhard Mueller

Pia will be starting a postdoc with Stefan Rosswog on binary neutron star mergers.

ESTEBAN JIMENEZ

University of Western Australia

Thesis title: The physical drivers of gas kinematics in galaxy formation simulations

ASTRO 3D Primary Supervisors: Claudia Lagos, Aaron Ludlow

GRACE LAWRENCE

Swinburne University of Technology

Thesis title: Dark Matter within Simulated Milky Way Analogues and the Subsequent Direct Detection Possibilities on Earth

Supervisors: Alan Duffy, Darren Croton, Chris Blake

After finishing her PhD at Swinburne University as a member of ASTRO 3D and of the ARC DMPP, Grace has started a post-doctoral research fellowship at University College London. As a part of the GMGalaxies team and the Cosmo-Particle Hub Initiative, Grace uses simulations to explore dark matter and its role in galaxy formation, as well as cross-disciplinary research in the particle physics arena.

ZEFENG LI

The Australian National University

Thesis title: Elemental Abundances from Optical and Infrared Spectra

Supervisors: Prof Mark Krumholz and cross-node collaborator, Claudia Lagos

Postdoc job in Durham University

SINEM OZBILGEN

University of Melbourne

Thesis title: Investigating the third parameter in the Tully Fisher Relationship

Supervisors: Prof. Rachel Webster and Prof Jeremy Mould

Sinem is now a senior scientific software engineer at ANSTO

WEI SHEN

The Australian National University

Thesis tile: Investigating the chemistry of stars in the Large Magellanic Cloud

Supevisors: Thomas Nordlander, Gary Da Costa, Dougal Mackey

At the moment I am currently unemployed as I am preparing for my wedding in a few months time. I will be looking for a job in the industry.

JUAN MANUEL ESPEJO SALCEDO

Swinburne University of Technology

Thesis title: The Role of Angular Momentum in the Evolution of Star-forming galaxies

Supervisors: Karl Glazebrook, Deanne Fisher, Sarah Sweet

In April, Juan started a postdoctoral position at the Max Planck Institute for Extraterrestrial Physics (MPE), in Garching (near Munich), Germany. He is part of the GALPHYS project, a multi-year program that focuses on the investigation of the internal drivers of galaxy evolution at the cosmic noon epoch. The goal is to use resolved spectroscopic observations of such galaxies with the recently commissioned near-IFU instrument ERIS at the VLT. His involvement in this project follows naturally from his PhD work at Swinburne under Karl Glazebrook's supervision.. He is very grateful for ASTRO 3D and the various opportunities of networking that it provided.

JI-JIA TANG

The Australian National University

Thesis title: Quasar Variability and Metallicity Gradient

Supervisor: A/Prof Christian Wolf

Student is working as a postdoc in National Taiwan University.

JESS THORNE

University of Western Australia

Thesis title: Lighting the night: The spectral energy distributions of galaxies

Supervisor: Aaron Robotham

DI WANG

University of Sydney

Thesis title: Spatial Resolving Galaxy Environmental Quenching in The

SAMI Galaxy Survey

Supervisors: Julia Bryant, Scott Croom

Di started a job as a data analyst in June 2023.

PURMORTAL (ZIXIAN) WANG

University of Sydney

Thesis title: The Milky Way as a Testbed for Galaxy Evolution

Supervisor: Prof. Joss Bland-Hawthorn

Purmortal has moved to a postdoc position with Anil Seth's group at the University of Utah.

TANNER WILSON

Monash University

Thesis title: Problems in Low-Mass Stellar Rotation

Supervisors: Andy Casey, Ilya Mandel

Tanner is looking for a job in industry to try it out for a while, but his long term plan is to return to academia.

KEY PERFORMANCE INDICATORS

CENTRE SPECIFIC KPI TARGETS	2017	2018	2019	2020	2021	2022	2023	2023 (ACTUALS)
1. Number of Research outputs	19	37	59	200	260	309	312	656
Journal articles	15	25	50	100	150	200	200	363
Media Releases	4	12	6	6	6	6	6	5
Virtual Reality Module	-	-	1	-	1	-	1	1
Datasets (e.g. SAMI, ASKAP, Genesis, MWA EoR, Galaxy Evolution, GALAH, MAGPI)	-	-	2	-	1	2	4	4
Data Intensive Middleware	-	-	-	1	-	-	-	-
ASVO Software	-	-	-	-	1	-	-	-
Science Explainer Videos	-	-	-	6	6	6	6	72
Website Blogposts/Updates	-	-	-	-	12	12	12	4
Facebook Page Posts	-	-	-	26	26	26	26	114
Twitter Page Posts	-	-	-	52	52	52	52	75
Public Program Exhibition	-	-	-	3	3	3	3	8
STEM Education Workshops/School Program	-	-	-	6	2	2	2	10
2. Quality of research outputs	80	80	80	80	80	80	80	100
Percentage of refereed papers in Journals with impact factor > 2.5	80	80	80	80	80	80	80	100
3. Number of workshops/conferences held/offered by the Centre	10	6	9	15	9	9	15	16
Professional Skills Workshop	1	1	1	1	1	1	1	3
Diversity Training Workshops	6	-	-	6	-	-	6	3
ECR Training Day	1	-	1	1	1	1	1	1
Writing Workshops	2	4	6	6	6	6	6	6
Transferrable Skills Workshop	-	1	1	1	1	1	1	3
4. Number of training courses held/offered by the Centre	5	7	7	7	7	14	14	20
Number of training courses held or offered by the Centre	3	3	3	3	3	10	10	1
International	1	2	2	2	2	2	2	3
National	1	2	2	2	2	2	2	2
5. Number of additional researchers working on Centre research	35	41	36	9	9	9	9	28
Postdoctoral Researchers	20	10	5	3	3	3	3	1
Honours Students	2	2	2	2	2	2	2	3
Masters by Coursework	2	2	2	2	2	2	2	2
PhD Students	6	12	12	1	1	1	1	21
Associate Investigators	5	15	15	1	1	1	1	2

6. Number of postgraduate completions	-	-	6	8	10	12	12	15
Annual Postgraduate Completions	-	-	6	8	10	12	12	15
7. Number of mentoring programs offered by the Centre	2	2	2	2	2	2	2	2
Centre-wide Mentoring Program	1	1	1	1	1	1	1	1
Women's Career Advancement Program	1	1	1	1	1	1	1	1
8. Number of Presentations/Briefings	56	96	96	96	96	96	96	364
To the public	20*	40	40	40	40	40	40	69
To government	4	4	4	4	4	4	4	3
To industry/business/end users	2	2	2	2	2	2	2	4
To non-government organisations	6	6	6	6	6	6	6	95
To professional organisations and bodies	4	4	4	4	4	4	4	36
Professional Conferences/workshops	20	40	40	40	40	40	40	226
9. Number of new organisations collaborating with, or involved in, the Centre	2	4	5	4	5	4	4	4
New collaborative relationships	2	4	4	4	4	4	4	4
New participating organisation	-	-	1	-	1	-	-	-
10. Other KPI - Maintain a collaborative and cohesive structure								
Percentage of cross node authorship of publications	50	85	85	85	85	85	85	51
Percentage of cross-node supervised PhD & ECRs	50	65	80	80	80	80	80	79
Project team meetings with cross-node participation	6	6	6	6	6	6	6	84
Centre wide climate survey	1	1	1	1	1	1	1	-
11. Other KPI Create a diverse Centre								
Percentage of females at all levels each year	30	35	40	45	50	50	50	48
Percentage of females receiving travel funds	30	35	40	45	50	50	50	52
Percentage of female visitors and speakers	50	50	50	50	50	50	50	71
Child care at ASTRO-3D supported conferences	All	All	All	All	All	All	All	All

* Note - Education and Outreach Affiliate Dr Brad Tucker did 1,055 Radio and TV interviews including Sky news, Channel 7 Sunrise and Evening news, WIN news, ABC Breakfast, ABC 24 and various radio stations across Australia. He also gave 166 Public talks which included School groups.

CONSOLIDATED FINANCIAL STATEMENT

NOTES TO FINANCIAL STATEMENT

1. ARC CONTRACT & GOVERNANCE

a. During the 2023 financial year, ASTRO 3D comprised nine Australian collaborating universities (nodes) and nine domestic and international partner organisations.

b. Funding was approved by the ARC for seven years, subject to review after four years. The Centre commenced operations on 1 July 2017, a six-month delay from the original 1 January commencement. The ARC conducted the mid-term review in June 2021 and approved future funding. In 2023, the Centre applied for, and was approved, a six-month extension on the original end date. The Centre will now cease operations on 31 Dec 2024.

c. From an operational and financial perspective, the Centre operates as a single entity, with the Australian National University, as the Administering Organisation, responsible for disbursing all funding provided by the ARC.

d. The Centre's operational and financial affairs are governed under defined policies and procedures.

e. Quarterly financial reporting tracks institutional expenditure at each node, with the Chief Operating Officer providing Consolidated Financial Reports for review by the Director.

2. INCOME

a. Income received from the ARC for 2023 amounted to $4.999m, including an indexation amount of $680k. All ARC contributions to the Centre have now been received.

b. University Contributions are contributions provided by the collaborating universities.

c. In 2023, ASTRO 3D received a $15,000 Federal Government grant in support of the Indigenous Work Experience program initiated at ANU. These funds have been rolled over into 2024 to fund the Winter School to be held at ANU in April.

d. Other 2023 income amounts to $241,374. This is revenue generated by conference registration payments, event sponsorships from other organisations, and reimbursements received by staff and students for ASTRO 3D-related travel and research expenses.

3. EXPENDITURE

a. Expenditure for the year was $7.054m, against a budget of $6.677m (106%). This variance is due primarily to the high inflation experienced over the past year.

b. The consolidated 2024 carry-forward balance of $5.548m will fund the Centre's final year of operations. All ARC funds will be expended in 2024. Modest University cash contributions will carry forward into 2025 to fund postdoctoral research contracts and PhD students who are scheduled to complete after the Centre's official end date.

	2023 ACTUAL ($)
INCOME	$
ARC Grant	4,999,033
State Government Grants	-
Other Grants	15,000
University Contributions	1,228,388
Partner Contributions	-
Other Income	241,374
Total Income	6,483,795
EXPENSES	
Salaries	4,936,576
Travel and Visitor Support	950,765
Equipment	-1,645
Workshops and Conferences	166,676
Management and Administration	657,474
Education, Outreach and Communications	145,561
PhD Support	198,318
TOTAL EXPENSES	7,053,725
NET SURPLUS (DEFICIT)	569,930
Brought Forward Balance	6,118,185
CARRY FORWARD BALANCE	5,548,255

ACRONYMS AND ABBREVIATIONS

AAO	Australian Astronomical Observatory
AAL	Astronomy Australia Ltd
AAT	Anglo Australian Telescope
ACFR	Australian Centre for Field Robotics
ADACS	Astronomy Data and Computing Services
ADC	Atmospheric Dispersion Corrector
AGN	Active Galactic Nuclei
AGEL	ASTRO 3D Galaxy Evolution with Lenses
ALFALFA	Arecibo Legacy Fast ALFA Survey
ALMA	Atacama Large Millimeter Array
ANU	The Australian National University
AOS	Australian Optical Society
APOGEE	APO Galactic Evolution Experiment
ARC	Australian Research Council
ASA	Astronomical Society of Australia
ASKAP	Australian Square Kilometre Array Pathfinder
ASTRO 3D	Centre of Excellence for All Sky Astrophysics in 3 Dimensions
ASTRON	Netherlands Institute for Radio Astronomy
ASVO	All-Sky Virtual Observatory
ATNF	Australia Telescope National Facility
BLM	Black Lives Matter
BoRG	Brightest of Reionising Galaxies
CAASTRO	Centre of Excellence for All Sky Astrophysics
CAS	Chinese Academy of Sciences
CASDA	CSIRO ASKAP Science Data Archive
CASS	CSIRO Astronomy and Space Science
CIRADA	Canadian Initiative for Radio Astronomy Data Analysis
CMB	Cosmic Microwave Background
COCKATOO	Cosmological Chemodynamical simulations with Kinetic AGN feedback and other physics TOO
COO	Chief Operating Officer
CRAM MWA	Central Redundant Array Mega-tile
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DALiuGE	Data Activated Liu Graph Engine
DECaLS	Dark Energy Camera Legacy Survey
DECRA	Discovery Early Career Researcher Award
DES	Dark Energy Survey
DIAP	Data Intensive Astronomy Program
DINGO	Deep Investigation of Neutral Gas Origins
DLA	Damped Lyman Alpha Absorber
DSTG	Defence Science and Technology Group
DUVET	Deep near-UV observations of Entrained gas in Turbulent galaxies
EAGLE	Evolution & Assembly of GaLaxies and their Environments
ECR	Early Career Researcher
EDI	Equity Diversity and Inclusion
EMP	Extremely Metal-poor Stars
EoR	Epoch of Reionisation
ESO	European Southern Observatory
ESPRESSO	Echelle SPectrograph for Rocky Exoplanets and Stable Spectroscopic Observations
FAST	Five-hundred-metre Apeture Spherical Telescope
FLASH	First Large Absorption Survey in HI
GALAH	GALactic Archeology with HERMES
GAMA	Galaxy and Mass Assembly
GECKOS	Generalising Edge-on galaxies and their Chemical bimodalities, Kinematics and Outflows out to Solar environments
GRB	Gamma Ray Burst
GMT	Giant Magellan Telescope
HERMES	High Efficiency and Resolution Multi-Element Spectrograph
HI	H one (neutral hydrogen)
HIRAX	Hydrogen Intensity and Real-time Analysis eXperiment
HITS	Heidelberg Institute for Theoretical Studies
HPC	High-Performance Computing
HST	Hubble Space Telescope
IAB	International Advisory Board
IAU	International Astronomical Union
ICRAR	International Centre for Radio Astronomy Research
IFU	Integral Field Unit
IGM	InterGalactic Medium
IMF	Initial Mass Function
ISM	InterStellar Medium
JWST	James Webb Space Telescope
K3-LARS	KMOS z=3-4 Lyα reference survey
KAPA	Keck All-sky Precision Adaptive-optics
KIAA	Kavli Institute for Astronomy and Astrophysics
KiDS	Kilo-Degree Survey
KMOS	K-band Object Spectrograph
KPI	Key Performance Indicator
KROSS	KMOS Redshift One Spectroscopic Survey
LIEF	Linkage Infrastructure Equipment and Facilities
LGBTI	Lesbian Gay Bisexual and Transgender (initalism)
LoBES	Long Baseline Epoch of Reionisation Survey
LOFAR	Low Frequency Array (currently largest radio telescope)
LTE	Local Thermodynamic Equilibrium
MAGPI	Middle Ages Galaxy Properties with Integral Field Spectroscopy
MANIFEST	Many Instrument Fiber System
MAUVE	MUSE and ALMA Unveiling the Virgo Environment
MIAPP	Munich Institute for Astro- and Particle Physics
MeerKAT	South African radio telescope, precursor to the Square Kilometre Array (SKA) telescope
MOSFIRE	Multi-Object Spectrograph For Infra-Red Exploration
MOSEL	MOSfire Emission Line survey
MPIA	Max Planck Institute for Astronomy
MSTO	Main Sequence Turn-Off
MUSE	Multi-Unit Spectroscopic Explorer
MWA	Murchison Widefield Array
NASA	National Aeronautics and Space Administration
NCA	National Committee for Astronomy
NCI	National Computational Infrastructure
NenuFar	New Extension in Nançay Upgrading LOFAR
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PHISCC	SKA Pathfinder HI Science Coordination Committee
QSO	Quasi-Stellar Objects
RGB	Red Giant Branch
RSAA	Research School for Astronomy and Astrophysics
SAGE	Semi-Analytic Galaxy Evolution
SAIL	Sydney Astrophotonic Instrumentation Laboratory
SAMI	Sydney-AAO Multi-object Integral field unit
SAM	Semi-Analytic Model
SCA	Subsea Communications Australia
SED	Spectral Energy Distribution
SKA	Square Kilometre Array
SKAO	Square Kilometre Array Observatory
SMC	Science Management Committee
SNR	Structured Supernova Remnants
SOfIA	Stratospheric Observatory for Infrared Astronomy
SpIRIT	Space Industry Responsive Intelligent Thermal) nanosatellite
SPIRIT	SPICE, Physics, ICRAR, Remote Internet Telescope
STARS	Scientists Taking Astronomy to Regional Schools
STEM	Science Technology Engineering Mathematics
TAO	Theoretical Astrophysical Observatory
TESS	Transiting Exoplanet Survey Satellite
TOSCA	Topology and Orchestration Specification for Cloud Applications
TYPHOON	An integral field spectroscopic (IFS) survey
UCSD	University of California San Diego
UNSW	University of New South Wales
UAV	Unmanned Aerial Vehicle
UoM	University of Melbourne
UV	UltraViolet
UW	University of Washington
UWA	University of Western Australia
VIKING	VISTA Kilo-Degree Infrared Galaxy Survey
VISTA	Visible and Infrared Survey Telescope for Astronomy
VLT	Very Large Telescope
VO	Virtual Observatory
VR	Virtual Reality
WALLABY	Widefield ASKAP L-Band Legacy Allsky Blind Survey
WiFeS	WideField Spectrograph

COLLOQUIA AND WORKSHOP TALKS, CONTRIBUTED AND INVITED TALKS, GOVERNMENT BRIEFINGS, POSTER PRESENTATIONS, SCHOOL AND OUTREACH TALKS, AND RADIO AND TV INTERVIEWS.

Image: ASTRO 3D Director Professor Emma Ryan-Weber in the ABC Radio Studios. Photo: supplied.

COLLOQUIA/WORKSHOP TALKS

Matthew Colless	Chief Investigator (CI)	London, UK	Galaxy structure and dynamics from integral field spectroscopy surveys	January
Michelle Cluver	Associate Investigator (AI)	Perth, Australia	Upcycling, Recycling, and Baryon Cycling	February
Henry Zovaro	Associate Investigator (AI)	Melbourne, Australia	Resolving ionised winds and thick disks in the SAMI Galaxy Survey	February
Sarah Martell	Chief Investigator (CI)	Sydney, Australia	Why do red giant branch stars destroy carbon (and does that matter for Galactic archaeology)?	February
Thorsten Tepper Garcia	Affiliate	Adelaide	Corrugations in stars and gas in the Milky Way	February
Michael Hayden	Associate Investigator (AI)	Tucson, Arizona, USA	Chemical Evolution of Disk Galaxies	March
Kim-Vy Tran	Affiliate	University of British Columbia, Vancouver, Canada	Illuminating the Dark Universe with Gravitational Lensing	March
Zixian Wang	Alumni	Biosphere 2, Tucson, AZ, US	GalCraft: Building an IFS data cube of the Milky Way	March
Sarah Brough	Affiliate	Brisbane, Australia	LOW SURFACE BRIGHTNESS ASTRONOMY AND THE RUBIN OBSERVATORY	March
Elaine Sadler	Chief Investigator (CI)	Munich, Germany	Optical follow-up of 21cm HI absorption surveys with SKA and its precursors	March
Manisha Caleb	Associate Investigator (AI)	Sydney, Australia	Exploring the transient landscape with Meerkat	March
Karen Lee-Waddell	Associate Investigator (AI)	Victoria, Canada	A new generation of radio surveys: WALLABY, ASKAP, and the AusSRC	April
Caroline Foster	Associate Investigator (AI)	ATNF, Marsfield, NSW, Australia	Challenges in understanding the dynamical evolution of galaxies	April
Ashley Ruiter	Associate Investigator (AI)	USyd	Mergers of white dwarfs and the transients they make	May
Michelle Cluver	Associate Investigator (AI)	Oxford, United Kingdom	Upcycling, Recycling, and Baryon Cycling	May
Kathryn Grasha	Fellow	Boston, United States	Non-solar scaled abundances for massive stars: the chemical abundance breakthrough for galaxy evolution	May
Emily Wisnioski	Chief Investigator (CI)	Melbourne, Australia	Connecting Epochs: how the chemo-dynamical evolution of disks over cosmic time is imprinted on local galaxies	May
Stefania Barsanti	Research Staff	Perth, Australia	"Galaxy kinematics within the cosmic web"	May
Emma Ryan-Weber	Chief Investigator (CI)	Fremantle, Australia	Director's update	May
Michael Hayden	Associate Investigator (AI)	Sussex, UK	4MOST Science Meeting: Survey Target Overlap	May
Sujeeporn Tuntipong	Student - PhD	Sydney, Australia	Milky Way Analogues: finding siblings of our Milky Way	May
Ashley Ruiter	Associate Investigator (AI)	CSIRO Sydney	Mergers of white dwarfs and the transients they make	June

Taissa Danilovich	Associate Investigator (AI)	Sydney, Australia	Using chemistry to constrain a (highly eccentric) binary orbit	June
Deanne Fisher	Chief Investigator (CI)	Gronningen, Netherlands	The Complex Views of Galaxy Winds	June
Deanne Fisher	Chief Investigator (CI)	Gronningen, Netherlands	Feedback and turbulence in disk galaxies	June
Deanne Fisher	Chief Investigator (CI)	Garching, Germany	Increasingly complex view of galaxy winds	June
Deanne Fisher	Chief Investigator (CI)	Garching, Germany	LGBT Experiences in Astronomy	June
Emma Ryan-Weber	Chief Investigator (CI)	Melbourne, Australia	The Chemical Evolution of the Universe	June
Stefania Barsanti	Research Staff	Durham, United Kingdom	"Galaxy kinematics within the cosmic web"	June
Stefania Barsanti	Research Staff	Nottingham, United Kingdom	"Galaxy kinematics within the cosmic web"	June
Stefania Barsanti	Research Staff	Cambdridge, United Kingdom	"Galaxy kinematics within the cosmic web"	June
Stefania Barsanti	Research Staff	Oxford, United Kingdom	"Galaxy kinematics within the cosmic web"	June
Jonah Gannon	Affiliate	Sesto, Italy	Ultra-Diffuse Galaxies (UDGs) and the Stellar Mass – Halo Mass Relationship	June
Jonah Gannon	Affiliate	Heidelberg, Germany	Ultra-Diffuse Galaxies (UDGs) and the Stellar Mass – Halo Mass Relationship	June
Jonah Gannon	Affiliate	Garching, Germany	Ultra-Diffuse Galaxies (UDGs) and the Stellar Mass – Halo Mass Relationship	June
Jonah Gannon	Affiliate	Munich, Germany	Ultra-Diffuse Galaxies (UDGs) and the Stellar Mass – Halo Mass Relationship	June
Jonah Gannon	Affiliate	Tenerife, Spain	Ultra-Diffuse Galaxies (UDGs) and the Stellar Mass – Halo Mass Relationship	June
Qianhui Chen	Student - PhD	Perth, Australia	Effects of Spiral Arms on Gas and Stellar Distributions	June
Luisa Buzzo	Student - PhD	Sesto, Italy	Why are UDGs interesting?	June
Yuxiang Qin	Research Staff	Canberra, Australia	AI for Astronomy - Emulating the model for fast Bayesian inference	June
Luisa Buzzo	Student - PhD	Innsbruck, Austria	Ultra-diffuse galaxies	July
Emily Kerrison	Student - PhD	Garching, Germany	Hunting for young obscured AGN using Bayesian SED fitting	July
Emily Kerrison	Student - PhD	Garching, Munich	Identifying young, obscured AGN using radio SED fitting	July
Darren Croton	Chief Investigator (CI)	Sydney, Australia	How to model the Universe in N easy steps (N>>1)	July
Stefania Barsanti	Research Staff	Munich, Germany	"Unveiling environmental quenching using SAMI, GAMA and eROSITA"	July
Caroline Foster	Associate Investigator (AI)	School of Physics, UNSW Sydney, Australia	the hundred-year-old (and my own much shorter) tale of solving for the 3D shape of galaxies	July
Madeline Howell	Student - PhD	Honolulu, USA & Aarhus, Denmark	First Asteroseismic Study of the Globular Cluster M80: Multiple Populations and Stellar Mass Loss	July
Sarah Martell	Chief Investigator (CI)	Munich, Germany	Chemical tagging: goals, methods, tools	August
Robert Adriel Mostoghiu Paun	Affiliate	Melbourne, Australia	Cosmological simulations and the search for dark matter	August
Emily Kerrison	Student - PhD	Nottingham, UK	Bayesian astronomy, better meetings and beyond the meeting room	August
Emily Kerrison	Student - PhD	London, UK	Hunting for young obscured AGN with Bayesian SED fitting	August
Xi Wang	Student - PhD	Stockholm, Sweden	3D NLTE Li measurements on GALAH	August
Xi Wang	Student - PhD	Uppsala, Sweden	The application of 3D NLTE grids to observations	August
Xi Wang	Student - PhD	Lund, Sweden	3D NLTE Li measurements on GALAH and ESPRESSO observations	August
Thomas Nordlander	Associate Investigator (AI)	Garching Munch, Germany	Finding the most metal-poor stars in the MW and LMC	August
Madeline Howell	Student - PhD	Honolulu, USA & Aarhus, Denmark	Studying Stellar Evolution using Asteroseismology of Red Giants in Globular Clusters	August
Thomas Nordlander	Associate Investigator (AI)	Garching Munch, Germany	Searching for metal-poor stars in the MW and LMC	August
Anshu Gupta	Fellow	Virtual	MOSEL Survey: Origin of extreme emission line galaxies in the early universe	August
Karen Lee-Waddell	Associate Investigator (AI)	Narrabri, Australia	Spectral Lines	September
Aman Khalid	Student - PhD	Melbourne, Australia	The Rubin Observatory in Simulated Universes: Characterising Tidal Features	September
Boquan Chen	Associate Investigator (AI)	Durham, UK	What we learned about the Milky Way from replicating the [alpha/Fe]-rise and [alpha/Fe]-bimodality	September
Boquan Chen	Associate Investigator (AI)	Liverpool, UK	What we learned about the Milky Way from replicating the [alpha/Fe]-rise and [alpha/Fe]-bimodality	September
Boquan Chen	Associate Investigator (AI)	Surrey, UK	What we learned about the Milky Way from replicating the [alpha/Fe]-rise and [alpha/Fe]-bimodality	September
Boquan Chen	Associate Investigator (AI)	Mullard Space Science Laboratory, London, UK	What we learned about the Milky Way from replicating the [alpha/Fe]-rise and [alpha/Fe]-bimodality	September
Jonah Gannon	Affiliate	Sydney, NSW	Ultra-Diffuse Galaxies and the Stellar mass-- halo mass relationship	September
Cathryn Trott	Chief Investigator (CI)	Melbourne, Australia	The ionization state of the Universe	September
Hyein Yoon	Affiliate	Sydney, Australia	ASKAP-FLASH: New Searches for Extragalactic HI 21-cm Absorption at $0.4 < z < 1.0$	September
Nandini Sahu	Research Staff	UNSW	1-How to model your galaxy	September
Cathryn Trott	Chief Investigator (CI)	Melbourne, Australia	The ionization state of the Universe	September

Joel Pfeffer	Affiliate	Melbourne, Australia	Kinematics and globular cluster system richness in UDGs: GC-poor galaxies are discs	October
Emma Ryan-Weber	Chief Investigator (CI)	Canberra, Australia	The Chemical Evolution and Reionisation of Galaxy Halos.	October
Ryan Bagge	Student - PhD	Perth, Australai	Physical Drivers of kinematic asymmetries in MAGPI galaxies.	October
Ryan Bagge	Student - PhD	Cambridge, England	Physical Drivers of kinematic asymmetries in MAGPI galaxies	October
Bronwyn Reichardt Chu	Affiliate	Sydney, Australia	How do outflows contribute to galaxy evolution?	October
Robert Adriel Mostoghiu Paun	Affiliate	Madrid, Spain	Cosmological simulations and the search for dark matter	October
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Paris, France	I ran a workshop at Paris Observatory: "Milky Way - connecting the near and far"	October
Deanne Fisher	Chief Investigator (CI)	Heidelberg, Germany	Feedback Regulate Star Formation in Turbulent Disk Galaxies	October
Michael Hayden	Associate Investigator (AI)	Melbourne, Australia	The Chemodynamic Structure and Evolution of the Milky Way	October
Michael Hayden	Associate Investigator (AI)	Sydney, Australia	The Chemodynamic Structure and Evolution of the Milky Way	October
Elaine Sadler	Chief Investigator (CI)	Munich, Germany	ASKAP-FLASH: A 21-cm search for HI in distant galaxies	October
Sven Buder	Fellow	Santiago, Chile	High-resolution spectroscopy in the optical with the GALAH Survey	October
Sven Buder	Fellow	Siding Spring Observatory, Coonabarabran	The GALAH Survey Data Release 4	October
Lydia Haacke	Student - PhD	Melbourne, Australia	The Globular Cluster System of NGC5846_UDG1	October
Aman Chokshi	Student - PhD	Paris-Saclay, France	The Necessity of Validated Beam Models for Epoch of Reionisation Science	November
Aman Chokshi	Student - PhD	Paris, France	The Necessity of Validated Beam Models for Epoch of Reionisation Science	November
Aman Chokshi	Student - PhD	Manchester, UK	The Necessity of Validated Beam models for Epoch of Reionisation Science	November
Balu Sreedhar	Student - PhD	Canberra, Australia	hydrogen in the first billion years: simulations of the epoch of reionisation	November
Stephanie Bernard	Student - PhD	Adelaide, AU	Archaeoastronomy workshop	November
Virginia Kilborn	Associate Investigator (AI)	Melbourne, Australia	Next generation HI surveys	November
Sarah Brough	Affiliate	Naples, Italy	Galaxy Evolution in a Low Surface Brightness Universe	November
Julia Bryant	Chief Investigator (CI)	Moreton Island, Australia	SAMI/Hector update	November
Sarah Martell	Chief Investigator (CI)	Canberra, Australia	When are globular clusters just very small galaxies?	November
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Kavli Institute for Cosmology, University of Cambridge, UK	Warps and corrugations in the Milky Way's disc	December
Michelle Cluver	Associate Investigator (AI)	Cape Town, South Africa	Unpacking the Nearby Universe	December
Aman Chokshi	Student - PhD	Lausanne, Switzerland	The Necessity of Validated Beam Models for Epoch of Reionisation Science	December
Aman Chokshi	Student - PhD	Groningen, Netherlands	The Necessity of Validated Beam Models for Epoch of Reionisation Science	December

CONTRIBUTED TALKS

Kim-Vy Tran	Affiliate	Seattle, Washington, USA	ASTRO 3D Guide to Inclusive Meetings	January
Kim-Vy Tran	Affiliate	Seattle, Washington, USA	The AGEL Survey: Strong Gravitational Lenses in the DES and DECaLS Fields	January
Aadarsh Pathak	Student - PhD	Adelaide, Australia	Analytical predictions for emission-line galaxy properties in the JWST-FRESCO survey	February
Hasti Nateghi	Student - PhD	Tempe, Arizona, USA	Tracking gas accretion in the CGM and IGM of galaxies	February
Darren Croton	Chief Investigator (CI)	Adelaide, Australia	### Searching for massive dead galaxies in the early universe	February
Daniel McPherson	Student - PhD	Kuala Lumpur, Malaysia	Resolved Images of Outflows in Edge-On Metal-Poor Starbursts	February
Takafumi Tsukui	Research Staff	Kyoto, Japan	Spatially resolved ISM properties and AGN-galaxy decomposition of HyLIRG at redshift 4.4	February
Ioana Ciuca	Research Staff	Kuala Lumpur, Malaysia	Chasing the impact of the last massive merger on the formation of the MW thick disc	February
Emily Wisnioski	Chief Investigator (CI)	Kuala Lumpur, Malaysia	Connecting Epochs: how the chemo-dynamical evolution of disks over cosmic time is imprinted on local galaxies	February
Hye-Jin Park	Student - PhD	Garching, Germany	Linking optical IFU data with multi-wavelength data: Probing the gas and dust evolution in galaxies	February
Jonghwan Rhee	Alumni	Garching, Germany	DINGO: Synergy of combining HI and multi-wavelength data	February
Nikki Nielsen	Fellow	Tempe, Arizona, USA	Directly Imaging CGM Structure out to 30kpc from a Starbursting Galaxy	February
Sarah Martell	Chief Investigator (CI)	Tucson, USA	What can we get away with?	March
Takafumi Tsukui	Research Staff	Tokyo, Japan	Spatially resolved ISM properties and AGN-galaxy decomposition of HyLIRG at redshift 4.4	March
Ioana Ciuca	Research Staff	Santa Barbara, California	Unsupervised Learning for Stellar Spectra with deep normalising flows	March

Jesse van de Sande	Associate Investigator (AI)	Tucson, US	The geckos survey - turning galaxy evolution on its side with deep observations of edge-on galaxies	March
Matthew Colless	Chief Investigator (CI)	Garching, Germany	Combining radio and optical peculiar velocity surveys from WALLABY and 4HS	March
Barbara Catinella	Chief Investigator (CI)	Garching, Germany	HI galaxy evolution in the SKA/ESO era	March
Emily Kerrison	Student - PhD	Online	Bayesian Radio SED fitting for multiwavelength AGN characterisation with SEAFOG	March
Sarah Martell	Chief Investigator (CI)	Sydney, Australia	Galactic Archaeology with MANIFEST + G-CLEF	April
Daniel McPherson	Student - PhD	Freemantle, Australia	Resolved Images of Outflows in Edge-On Metal-Poor Starbursts	May
Miftahul Hilmi	Student - PhD	Fremantle, Australia	A novel analysis of contamination in Lyman break galaxy samples based on spatial cross-correlation with intermediate-redshift galaxies	May
Aishwarya Selvaraj	Student - PhD	Perth, Australia	Improved foreground mitigation with the Central Redundant Array Mega-tile (CRAM	May
Alma Sebastian	Student - PhD	Fremantle, Australia	The cosmic evolution of low ionisation absorbers using XQR-30	May
Nikki Nielsen	Fellow	Perth, Australia	Revealing the ISM-CGM Transition with Direct CGM Emission Mapping	May
Luisa Buzzo	Student - PhD	Perth, Australia	The stellar populations of ultra-diffuse galaxies	May
Antonia Fernandez Figueroa	Student - PhD	Freemantle, Australia	The circumgalactic medium in different group environments	May
Kathryn Grasha	Fellow	Paralia Katerini, Greece	Exploiting James Webb Space Telescope Observations of the First Galaxies	May
Darren Croton	Chief Investigator (CI)	Fremantle, Australia	Using the star-forming main sequence to explore quiescent galaxies across cosmic time	May
Madusha Gunawardhana	Research Staff	North Ryde, Australia	Hector data reduction pipeline - modelling the chromatic variations in distortion due to AAT top end optics	May
Bronwyn Reichardt Chu	Affiliate	Fremantle, Australia	Constraining star formation feedback with DUVET	May
Simon Weng	Student - PhD	Lyon, France	Gas flows in the CGM from observations and simulations	May
Yuxiang Qin	Research Staff	perth, australia	Implications of z>~12 JWST galaxies for galaxy formation at high redshift	May
Kristan Boyett	Fellow	Paralia, Greece	A massive interacting galaxies 525 million years after the Big Bang	May
Henry Zovaro	Associate Investigator (AI)	Melbourne, Australia	Resolving winds in the SAMI galaxy survey	May
Aadarsh Pathak	Student - PhD	Perth, Australia	Analytical predictions for emission-line galaxy properties in the JWST-FRESCO survey	June
Balu Sreedhar	Student - PhD	Heidelberg, Germany	Constraining the astrophysics of the early Universe with 21-cm power spectra	June
Aman Khalid	Student - PhD	Paris, France	Tidal Features Around Galaxies in Cosmological Simulations	June
Lydia Haacke	Student - PhD	Sesto, Italy	The Globular Cluster System of NGC5846_UDG1	June
Tania Barone	Research Staff	Otranto, Italy	Using lenses to study the gas around quiescent galaxies	June
Rebecca Davies	Research Staff	Boston, USA	XQR-30: Metal Absorbers Probing Chemical Enrichment and Outflows at z > 5	June
Nandini Sahu	Research Staff	Otranto, Italy	Is the Conflict Real? Testing Galaxy Formation and Dark Matter Models with Strong Gravitational Lenses at 0.3 < z < 0.9	June
Yuxiang Qin	Research Staff	Heidelberg Germany	Probing reionisation with Lyman-alpha forests and emitters	June
Hasti Nateghi	Student - PhD	Hobart, Tasmania, Australia	The kinematics of gas flows in the CGM and galaxy disk derived from HI absorption	June
Aishwarya Selvaraj	Student - PhD	Perth, Australia	Improved foreground mitigation with the Central Redundant Array Mega-tile (CRAM)	June
Yuxiang Qin	Research Staff	Canberra, Australia	Emulating cosmological models using neural networks	June
Miftahul Hilmi	Student - PhD	Hamamatsu, Japan	A novel analysis of contamination in Lyman break galaxy samples at z ~ 6 - 8: spatial correlation with intermediate-redshift galaxies at z ~ 1.3 - 2	July
Jae Yeon Mun	Student - PhD	Sydney, Australia	Unifying observations and theory: Investigating radial trends in star formation across cosmic time with the MAGPI survey	July
Alma Sebastian	Student - PhD	Healesville, Australia	The chemical enrichment in galaxy halos across cosmic time using XQR-30	July
Anshu Gupta	Fellow	Perth, Australia	MAGPI Survey: Detecting intragroup medium in ionised emission	July
Jesse van de Sande	Associate Investigator (AI)	Granada, Spain	GECKOS: Turning galaxy evolution on its side with deep observations of edge-on galaxies with and without bars	July
Emily Kerrison	Student - PhD	Sydney, Australia	Hunting for young obscured AGN with Bayesian SED fitting	July
Katherine Harborne	Affiliate	Krakow, Poland	Biases in kinematic training data: Things to consider when building machine learning models trained on IFU data	July

Katherine Harborne	Affiliate	Krakow, Poland	SimSpin: Formatting galaxy simulation data for compatibility with observational surveys	July
Antonia Fernandez Figueroa	Student - PhD	Healesville, Australia	The circumgalactic medium in different group environments	July
Benjamin Metha	Student - Masters	Sydney, Australia	Geostatistics of Galaxies: A novel approach to understand multiscale metallicity variations	July
Jennifer Alyce Hardwick	Alumni	Sydney, Australia	The connection between galaxy angular momentum and gas fraction in both observations and simulations	July
Jennifer Alyce Hardwick	Alumni	Krakow, Poland	The connection between galaxy angular momentum and atomic gas content in both observations and simulations	July
Sabrina Berger	Student - PhD	Marseilles, France	Constraining properties of high-z quasar hosts with JWST	July
Sabrina Berger	Student - PhD	Sesto, Italy	Constraining properties of high-z quasar hosts with JWST	July
Taissa Danilovich	Associate Investigator (AI)	Sydney, Australia	Using astrochemistry to understand orbital properties of AGB stars	July
Amanda Karakas	Chief Investigator (CI)	Sextens, Italy	Stellar yields from single and binary AGB stars	July
Hyein Yoon	Affiliate	Stanley, USA	New Searches for HI 21-cm Absorption at 0.4 < z < 1.0: Results from ASKAP-FLASH Pilot Surveys	July
Hyein Yoon	Affiliate	Sydney, Australia	Results from the FLASH Pilot Surveys: ASKAP HI 21-cm absorption observations toward 0.42 < z < 1.00	July
Julia Bryant	Chief Investigator (CI)	Sydney, Australia	The Hector Galaxy Survey - the AAT's new large integral-field spectroscopic dark-time survey	July
Barbara Mazzilli Ciraulo	Research Staff	Healesville, Australia	Resolved multi-phase outflows in starbursting galaxies	July
Tomas Rutherford	Student - PhD	Sydney, Australia	Using Streams and Shells to Trace the Dynamical Evolution of Massive Galaxies	July
Emily Wisnioski	Chief Investigator (CI)	Krakow, Poland	Connecting Epochs: how the chemo-dynamical evolution of disks over cosmic time is imprinted on local galaxies	July
Daniel McPherson	Student - PhD	Healesville, Australia	Resolved Images of Outflows in Edge-On Metal-Poor Starbursts	July
Magdalena Hamel Bravo	Student - PhD	Healesville, Australia	Metallicity measurements in outflows	July
Nikki Nielsen	Fellow	Healesville, Vic, Australia	Directly Imaging the CGM Out to 30 kpc from a Starbursting Galaxy	July
Stefania Barsanti	Research Staff	Krakov, Poland	"Impact of bulge formation and black hole activity on galaxy spin-filament alignments"	July
Chien-Chang Ho	Student - PhD	Perth, Australia	Future Constraints on Dark Matter with Gravitationally Lensed Fast Radio Bursts Detected by BURSTT' ACAMAR9 Workshop	July
Tania Barone	Research Staff	Healseville, Australia	Using galaxy-scale lenses to study the CGM of quiescent galaxies	July
Rebecca Davies	Research Staff	Sydney, Australia	JWST reveals significant neutral gas absorption in massive z~2 galaxies	July
Bronwyn Reichardt Chu	Affiliate	Healesville, Australia	DUVET: How galaxies self-regulate star formation with outflows	July
Rebecca Davies	Research Staff	Perth, Australia	JWST reveals significant neutral gas absorption in massive z~2 galaxies	July
Nandini Sahu	Research Staff	Krakow, Poland	The AGEL Survey: Strong Gravitational Lenses in the DES and DECaLS Fields	July
Nandini Sahu	Research Staff	Krakow, Poland	Is the Conflict Real? Testing Galaxy Formation and Dark Matter Models with Strong Gravitational Lenses at 0.3 < z < 0.9	July
Aditya J N H S	Research Staff	Melbourne, Australia	COLD GAS outflows as detected in HI 21cm absorption	July
Aditya J N H S	Research Staff	Sydney, Australia	COLD GAS in the Surroundings of AGN	July
Julia Bryant	Chief Investigator (CI)	Sydney, Australia	The Hector Galaxy Survey – the AAT's new large integral-field spectroscopic dark-time survey	July
Deanne Fisher	Chief Investigator (CI)	Ascona, Switzerland	Feedback in Gas Rich Disk Galaxies	July
Giulia Santucci	Affiliate	Krakow, Poland	Environmental analysis of the internal orbital structures of SAMI passive galaxies	July
Yifan Mai	Student - PhD	Wollongong, Australia; Canberra, Australia	Drivers of gas turbulence in MAGPI and SAMI galaxies	July
Yuxiang Qin	Research Staff	Sydney, Australia	Implications of >~12 JWST galaxies for galaxy formation at high redshift	July
Karen Lee-Waddell	Associate Investigator (AI)	Koriyama, Japan	Neutral hydrogen in the host galaxies of FRBs	August
Aadarsh Pathak	Student - PhD	Koriyama city, Japan	Analytical predictions for emission-line galaxy properties in the JWST-FRESCO survey	August
Sarah Martell	Chief Investigator (CI)	Munich, Germany	Lithium-rich giants in large surveys	August
Caroline Foster	Associate Investigator (AI)	Koriyama, Japan	The MAGPI Survey: on the physical drivers of morphological transformation, kinematic and visual disturbances at intermediate redshift	August
Elaine Sadler	Chief Investigator (CI)	Koriyama, Japan	Neutral hydrogen in the distant Universe - new results from the ASKAP FLASH survey	August

Luisa Buzzo	Student - PhD	Koriyama, Japan	The stellar populations of ultra-diffuse galaxies	August
Rebecca Davies	Research Staff	Fukushima, Japan	XQR-30: Metal Absorbers Probing Chemical Enrichment and Outflows at z > 5	August
Randall Wayth	Associate Investigator (AI)	Sapporo, Japan	Aperture efficiency of beamforming with mutual coupling in SKA-Low stations	August
Xi Wang	Student - PhD	Garching, Germany	3D NLTE Li abundances for GALAH	August
Christopher Jordan	Research Staff	Sapporo, Japan	A census of ionospheric activity observed by the Murchison Widefield Array	August
Jack Line	Research Staff	Sapporo, Japan	Australian EoR Pipeline verification and (not) all-sky 21 cm sky maps	August
Andrew Battisti	Affiliate	Busan, South Korea	Sharpening our view of Dust Attenuation using TYPHOON	August
Henry Zovaro	Associate Investigator (AI)	Virtual	Probing the origins of multiple emission line components in star-forming galaxies	August
Darren Croton	Chief Investigator (CI)	Canberra, Australia	Using the star-forming main sequence to explore quiescent galaxies across cosmic time	September
Aman Khalid	Student - PhD	Sydney, Australia	LSST in Simulated Universes: Tidal Features	September
Ryan Bagge	Student - PhD	Porto Ercole, Italy	The MAGPI Survey: The role of environment in driving kinematics and morphological transformation	September
Boquan Chen	Associate Investigator (AI)	Cambridge, UK	What we learned about the Milky Way from replicating the [alpha/Fe]-rise and [alpha/Fe]-bimodality	September
Bronwyn Reichardt Chu	Affiliate	Canberra, Australia	Constraining star formation feedback with DUVET	September
Barbara Mazzilli Ciraulo	Research Staff	Canberra, Australia	Mapping resolved outflows in edge-on starbursting galaxies	September
Jae Yeon Mun	Student - PhD	Canberra, Australia	Unifying observations and theory: Investigating radial trends in star formation across cosmic time with the MAGPI survey	September
Alma Sebastian	Student - PhD	Canberra, Australia	XQR-30: The cosmic evolution of MgII, CII and OI in galaxy halos	September
Magdalena Hamel Bravo	Student - PhD	Canberra, Australia	Measuring metallicity in outflows	September
Elaine Sadler	Chief Investigator (CI)	Canberra, Australia	Connecting HI and star formation across cosmic time with ASKAP-FLASH	September
Jesse van de Sande	Associate Investigator (AI)	Canberra, Australia	The geckos survey: turning galaxy evolution on its side with deep observations of edge-on galaxies	September
Katherine Harborne	Affiliate	Canberra, Australia	The MAGPI Survey: A theoretical look at the evolution of galaxy shapes across the last 3-4 Gyr	September
Rebecca Davies	Research Staff	Canberra, Australia	New insights into star-formation quenching from JWST neutral gas observations	September
Stefania Barsanti	Research Staff	Porto Ercole, Italy	Galaxy kinematics within the cosmic web: spin-filament alignments to unravel the evolution of galaxies and their components	September
Stefania Barsanti	Research Staff	Canberra, Australia	Galaxy kinematics within the cosmic web: spin-filament alignments to unravel the evolution of galaxies and their components	September
Xi Wang	Student - PhD	Florence, Italy	Ending the second cosmological Li problem with ESPRESSO	September
Barbara Catinella	Chief Investigator (CI)	Porto Ercole, Italy	The link between atomic and molecular gas stripping and quenching in satellite galaxies at different infall stages	September
Barbara Catinella	Chief Investigator (CI)	Canberra, Australia	Galaxy transformation in clusters: tracking cold gas stripping and quenching of satellites during infall	September
Giulia Santucci	Affiliate	Canberra, Australia	Connecting the stellar orbital distributions of galaxies with their evolution history	September
Taissa Danilovich	Associate Investigator (AI)	Daejeon, South Korea	Isotopic ratios from (sub)millimetre observations of AGB stars	September
Luca Cortese	Associate Investigator (AI)	Canberra, Australia	MAUVE - MUSE and ALMA unveiling the Virgo Environment	September
Zara Osborn	Student - PhD	Daejeon, South Korea	The Impact of Binary Evolution on Stellar Nucleosynthesis	September
Nandini Sahu	Research Staff	UNSW	Morphology-dependent Black Hole Mass Scaling Relations	September
Hasti Nateghi	Student - PhD	Caltech, USA	Connecting the kinematics of HI CGM gas flows to galaxy rotation	September
Sarah Martell	Chief Investigator (CI)	Melbourne, Australia	When are globular clusters just very small galaxies?	October
Jesse van de Sande	Associate Investigator (AI)	Paris, France	Bimodality in nearby galaxies	October
Jesse van de Sande	Associate Investigator (AI)	Puerto de la Cruz, Spain	The GECKOS Survey?Turning galaxy evolution on its side with highly resolved stellar population?measurements of edge-on galaxies	October
Bronwyn Reichardt Chu	Affiliate	Sydney, Australia	Constraining star formation feedback with DUVET	October
Antonia Fernandez Figueroa	Student - PhD	Melbourne, Australia	The circumgalactic medium in different group environments	October
Duncan Forbes	Affiliate	Melbourne, Australia	Stellar Mass Halo Mass Relation	October
Andrew Battisti	Affiliate	Amherst, USA	Sharpening our view of dust attenuation across cosmic time	October
Aditya J N H S	Research Staff	China	FLASH: ASKAP Survey for HI 21cm absorption at intermediate redshifts	October
Emma Ryan-Weber	Chief Investigator (CI)	Melbourne, Australia	Gender Equity in ASTRO 3D	November

Adam Ussing	Student - PhD	Adelaide, Australia	Cosmic dust as a dark matter discriminator	November
Alma Sebastian	Student - PhD	Santiago, Chile	E-XQR-30: The cosmic evolution of MgII, CII and OI	November
Randall Wayth	Associate Investigator (AI)	Sydney, Australia	A portable many element coherent receiver for passive radar and space domain awareness	November
Tomas Rutherford	Student - PhD	Sydney, Australia	Tracing the dynamic history of massive galaxies with shells	November
Rebecca Davies	Research Staff	Santiago, Chile	XQR-30: Enrichment of the CGM by Outflows at z > 5	November
Barbara Mazzilli Ciraulo	Research Staff	Tokyo, Japan	Resolved multiphase outflows in starbursting galaxies	November
Steven Janssens	Affiliate	Kooyong, Australia	A handful of GC-rich UDGs in Perseus as revealed by HST	November
Michael Hayden	Associate Investigator (AI)	Wollongong, Australia	The Chemical Evolution of Disk Galaxies	November
Antonia Fernandez Figueroa	Student - PhD	Canberra, Australia	The circumgalactic medium of galaxy pairs	November
Sven Buder	Fellow	Wollongong, Australia	Chronochemodynamics of Milky Way Stellar Populations with the GALAH Survey	November
Jeff Cooke	Associate Investigator (AI)	Hawaii, USA	The Keck Wide-Field Imager: The most powerful wide-field optical imager for the foreseeable future and what it can do for you	December
Jeff Cooke	Associate Investigator (AI)	Sydney, Australia	WST transients	December
Jeff Cooke	Associate Investigator (AI)	Los Angeles, USA	"The high utility of high-redshift supernovae"	December
Tomas Rutherford	Student - PhD	Perth, Australia	Identifying merger features in galaxy populations with SAMI - What role do mergers play in the formation pathway of slow rotators?	December

GOVERNMENT BRIEFINGS

Emma Ryan-Weber	Chief Investigator (CI)	Canberra, Australia	ASTRO 3D - incoming director presentation	February
Jeff Cooke	Associate Investigator (AI)	Hawthorn, Victoria, Australia	S20 - Astroinformatics for Sustainable Development: Sky Surveys	July
Caroline Foster	Associate Investigator (AI)	Macquarie University, NSW, Australia	ESO and Data Central Synergies: the case of the MAGPI Survey	December

INVITED TALKS

Ioana Ciuca	Research Staff	Potsdam, Germany	New Insights into the Chemical Evolution of Our Galaxy using Machine Learning	January
Bi-Qing For	Associate Investigator (AI)	Kuala Lumpur, Malaysia	ASKAP WALLABY Survey	January
Glenn Kacprzak	Associate Investigator (AI)	Ringberg, Germany	Connecting galaxy kinematics to the HI in the CGM: Signatures of Gas Flows I	February
Claudia Lagos	Fellow	Online	Modelling HI emission lines and radio continuum from star formation and AGN in cosmological galaxy formation simulations	March
Emily Wisnioski	Chief Investigator (CI)	Garching, Germany	Galaxy Evolution: Linking H I and optical /NIR resolved galaxy studies in the disk settling epoch	March
Jeff Cooke	Associate Investigator (AI)	Toronto, Canada	DWF: Fast transients and the nature of FRBs	April
Rebecca Davies	Research Staff	Minneapolis, USA	Feedback from accreting supermassive black holes in the early Universe	April
Scott Croom	Chief Investigator (CI)	online - based at AAO-MQ	Viewing the build up of the Hubble sequence through stellar kinematics	April
Takafumi Tsukui	Research Staff	Peking, China	Using ALMA as a thermometer for black hole and galaxy co-evolution	April
Scott Croom	Chief Investigator (CI)	online - based at AAO-MQ	Viewing the build up of the Hubble sequence through stellar kinematics	April
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Fresnel Institute, Marseille, France	Quantum telescopes - the future of interferometry	April
Ioana Ciuca	Research Staff	Hull, United Kingdom	Unsupervised Learning for Stellar Spectra with deep normalising flows	April
Jesse van de Sande	Associate Investigator (AI)	Berkeley, US	The build-up of mass and angular momentum in galaxies like our Milky Way	April
Jesse van de Sande	Associate Investigator (AI)	Davis, US	The build-up of mass and angular momentum in galaxies like our Milky Way	April
Themiya Nanayakkara	Affiliate	Perth, Australia	How JWST is unveiling the early cosmos	May
Sarah Martell	Chief Investigator (CI)	Fremantle, Australia	The GALAH Survey: Science Update	May
Jeff Cooke	Associate Investigator (AI)	Hawthorn, Victoria, Australia	Capitalising on Rubin and Fink's speed	May
Nikki Nielsen	Fellow	Sydney, Australia	Revealing the Circumgalactic Medium with Direct Emission Mapping	May
Michael Hayden	Associate Investigator (AI)	Uppsala, Sweden	Chemodynamics and Evolution of the Milky Way	May
Jack Line	Research Staff	Nazareth, Israel	Recent EoR Results from the MWA	May
Jaiden Cook	Student - PhD	Vancouver, Canada; Seattle, United States of America; Montreal, Canada; Groningen, Netherlands	Advanced statistical methods for detecting the epoch of reionisation	May
Balu Sreedhar	Student - PhD	Cosmic Dawn, Copenhagen, Denmark	Simulating the epoch of reionisation	June
Balu Sreedhar	Student - PhD	SNS, Pisa, Italy	Simulating the epoch of reionisation	June

Richard McDermid	Chief Investigator (CI)	Sydney, Australia	Problems of Astronomical Proportions: Research Challenges in the Era of Data-Intensive Astronomy	June
Lydia Haacke	Student - PhD	Sesto, Italy	The Globular Cluster System of NGC5846_UDG1	June
Luisa Buzzo	Student - PhD	Sesto, Italy	The stellar populations of ultra-diffuse galaxies	June
Katherine Harborne	Affiliate	Canberra, Australia	SimSpin: Formatting galaxy simulation data for compatibility with observational surveys	June
Deanne Fisher	Chief Investigator (CI)	Garching, Germany	What drives Turbulence in Galaxies	June
Cathryn Trott	Chief Investigator (CI)	Heidelberg, Germany	21cm observations: Current program and future prospects	June
Yifan Mai	Student - PhD	Australia	Drivers of gas turbulence of MAGPI, SAMI and KROSS galaxies	June
Jesse van de Sande	Associate Investigator (AI)	Groningen, The Netherlands	GECKOS: Turning galaxy evolution on its side with deep observations of edge-on galaxies	June
Anshu Gupta	Fellow	Marseille, France	Mosel Survey: Extremely Weak Outflows in Epoch of Reionisation Analogues at z~3	July
Michelle Cluver	Associate Investigator (AI)	Sydney, Australia	Levelling up the Southern Hemisphere: Breathing new life into VISTA and WISE	July
Barbara Catinella	Chief Investigator (CI)	Perth, Australia	Cold gas surveys at z~0: statistical studies	July
Barbara Catinella	Chief Investigator (CI)	Healesville, Victoria, Australia	Insights on the baryon cycle from cold gas surveys	July
Hyein Yoon	Affiliate	Perth, Australia	ASKAP-FLASH Pilot Surveys: Searching for HI 21-cm Absorption toward 0.42 < z < 1.00	July
Emily Wisnioski	Chief Investigator (CI)	Krakow, Poland	Results and questions after a decade+ of IFS galaxy surveys beyond z=0	July
Deanne Fisher	Chief Investigator (CI)	Perth, Australia	Molecular Gas in Galaxies	July
Deanne Fisher	Chief Investigator (CI)	Rekjavik, Iceland	LGBT Considerations in Astronomy	July
Deanne Fisher	Chief Investigator (CI)	Rekjavik, Iceland	Complex View of Outflows in Galaxies	July
Emma Ryan-Weber	Chief Investigator (CI)	Healesville, Australia	The effect of Reionisation on the high-z CGM	July
Rebecca Davies	Research Staff	Marseille, France	Metal absorbers probing outflows and chemical enrichment in the early Universe	July
Rebecca Davies	Research Staff	Healesville, Australia	Widespread Neutral Gas Outflows in Massive z~2 Galaxies Revealed by JWST	July
Deanne Fisher	Chief Investigator (CI)	Ringberg, Germany	Feedback Regulated Star Formation in Gas Rich Disks	July
Hasti Nateghi	Student - PhD	Stanley, Idaho, USA	Connecting the Kinematics of HI CGM Gas Flows to Galaxy Rotation	August
Bi-Qing For	Associate Investigator (AI)	Sapparo, Japan	ASKAP WALLABY Survey	August
Cathryn Trott	Chief Investigator (CI)	Sapporo, Japan	Commission J Tutorial: Hunting for Signals from the Infant Universe	August
Deanne Fisher	Chief Investigator (CI)	Bern, Switzerland	What we can learn from clumps in DYNAMO galaxies	August
Richard McDermid	Chief Investigator (CI)	Sydney, Australia	Exploring Our Complex Cosmos with Next-Generation Telescopes in the Age of Data-Intensive Astronomy	August
Balu Sreedhar	Student - PhD	CCA, New York, USA	Constraining the astrophysics of the early Universe with 21-cm power spectra	September
Sarah Martell	Chief Investigator (CI)	Sydney, Australia	Machine learning and data science techniques in Galactic archaeology	September
Sam Vaughan	Research Staff	Oxford University, Oxford, UK	The kinematics and stellar populations of nearby galaxies from the SAMI galaxy survey	September
Glenn Kacprzak	Associate Investigator (AI)	Kylemore, Ireland	Connecting galaxy kinematics to the CGM	September
Manodeep Sinha	Research Staff	Melbourne, Australia	Invited member for "Strategy & Policy" Panel	September
Cathryn Trott	Chief Investigator (CI)	Perth, Australia	The SKA EoR Experiments	September
Luca Cortese	Associate Investigator (AI)	Porto Ercole, Italy	Environment in Resolved Scaling Relations	September
Amanda Karakas	Chief Investigator (CI)	Daeojeon, Korea	The s-process in asymptotic giant branch stars	September
Simon Weng	Student - PhD	Kylemore, Ireland	The origins of absorbers in the CGM from simulations and observations	September
Nikki Nielsen	Fellow	Kylemore, Ireland	Tracing gas flows with direct CGM emission	September
Sven Buder	Fellow	Perth, Australia	Chronochemodynamics of Milky Way Stellar Populations with the GALAH Survey	September
Emma Ryan-Weber	Chief Investigator (CI)	Melbourne, Australia	The Chemical Evolution of the Universe	October
Michael Hayden	Associate Investigator (AI)	Paris, France	Chemical Bimodality in the Milky Way	October
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Paris, France	Warps, bending waves and corrugations in the Milky Way	October
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Institut d'Astrophysique, Paris, France	A new experiment in near-field cosmology	October
Benjamin Metha	Student - Masters	Online, Australia	Geostatistics of Galaxies -- a novel approach to understanding multiscale metallicity fluctuations in IFS data	October
Deanne Fisher	Chief Investigator (CI)	Garching, Germany	Feedback from clumps in Gas Rich Galaxies	October

Jaiden Cook	Student - PhD	Asheville, North Carolina, United States of America	Investigating the Contribution of Extended Widefield Sources to the Epoch of Reionisation	November
Sarah Brough	Affiliate	Bern, Switzerland	The Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST)	November
Tayyaba Zafar	Associate Investigator (AI)	Sydney, Australia	SHATTERING THE GLASS UNIVERSE: INCLUSIVITY IN ASTRO 3D	November
Gary Da Costa	Associate Investigator (AI)	ASTRO 3D Retreat, Moreton Island, QLD	First Stars Project Science Update	November
Elaine Sadler	Chief Investigator (CI)	Adelaide, Australia	Flexible work – experiences from astronomy	November
Sven Buder	Fellow	Santiago, Chile	Galactic Archaeology with the GALAH Survey	November
Adam Batten	Affiliate	Adelaide, Australia	How to not make your PhD your entire life... And actually finish it!	November
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Durham University, UK	Turbulent disk galaxies at the dawn of time	December
Benjamin Metha	Student - Masters	Los Angeles, USA	Geostatistics of Galaxies -- Making the Most of Metallicity Maps	December
Julia Bryant	Chief Investigator (CI)	ANU, Canberra	Development of fibre technologies for WST	December
Julia Bryant	Chief Investigator (CI)	Hong Kong	The Hector Galaxy Survey - A new large IFS survey of galaxies at z<0.1	December

MEDIA, RADIO, PRESS OR TV INTERVIEWS

Rebecca Davies	Research Staff	Online, Australia	Black holes shed light on carbon in the early universe	March
Emma Ryan-Weber	Chief Investigator (CI)	Ballarat, Australia	Solar Eclipse	April
Emma Ryan-Weber	Chief Investigator (CI)	Ballarat, Australia	Ballarat Observatory School holiday activity	April
Jeff Cooke	Associate Investigator (AI)	Hawthorn, Victoria, Australia	The Sound of Progress: Data Sonification, Space, and Accessibility	May
Randall Wayth	Associate Investigator (AI)	Perth, Australia	TV interview on Space Domain Awareness system for APAC network	May
Ravi Jaiswar	Student - PhD	Perth,Australia	Smart Enough to Dream Wizards - Podcast	July
Michelle Cluver	Associate Investigator (AI)	Melbourne, Australian	Things that go bump in the mid-infrared	August
Benjamin Metha	Student - Masters	Melbourne, Australia	Space Junk -- live on RRR	August
Zara Osborn	Student - PhD	Gembrook, Australia	Footy Oval Astronomy	August
Kathryn Grasha	Fellow	Canberra, Australia	Stars in their eyes	August
Barbara Mazzilli Ciraulo	Research Staff	France	The death of the galaxies.	August
Barbara Mazzilli Ciraulo	Research Staff	Melbourne, Australia	"La mort subite d'une galaxie" "Au plus près du Big Bang : la nouvelle histoire par JWST"	September
Karen Lee-Waddell	Associate Investigator (AI)	Perth, Australia	video to promote YTP award recipients	October
Jeff Cooke	Associate Investigator (AI)	Online, Australia	Luminous Fast Blue Optical Transient (LFBOT)	November
Emma Ryan-Weber	Chief Investigator (CI)	Melbourne, Australia	Gender Parity in ASTRO 3D	November
Randall Wayth	Associate Investigator (AI)	Perth, Australia	Interview with "Cosmic Corner" podcast.	November
Rebecca Davies	Research Staff	Melbourne, Australia	Galactic Outflows	November

POSTER PRESENTATIONS

Miftahul Hilmi	Student - PhD	Kuala Lumpur, Malaysia	A Novel Analysis of Contamination in Lyman Break Galaxy Samples at z ~ 6 – 8: Spatial Correlation with Intermediate-redshift Galaxies at z ~ 1.3 – 2	February
Antonia Fernandez Figueroa	Student - PhD	Tempe, Arizona, USA	The circumgalactic medium in different group environments	February
Qianhui Chen	Student - PhD	Kuala Lumpur, Malaysia	Difference in the distribution of ISM properties with MAGPI at z~0.3	February
Lara Sharp	Professional Staff	Canberra, Australia	Sketches of Science - Helping make science accessible	February
Andrew Battisti	Affiliate	Baltimore, USA	MAGPI Survey	April
Karen Lee-Waddell	Associate Investigator (AI)	Vancouver, Canada	AusSRC	May
Lydia Haacke	Student - PhD	Freemantle, Australia	The Globular Cluster system of NGC5846_UDG1	May
Barbara Mazzilli Ciraulo	Research Staff	Fremantle, Australia	Resolved multi-phase outflows in starbursting galaxies	May
Takafumi Tsukui	Research Staff	Vancouver, Canada	Estimating the statistical uncertainty due to spatially correlated noise in interferometric images	May
Hasti Nateghi	Student - PhD	Online, Australia	Connecting the kinematics of multiphase CGM gas flows to galaxy rotation using HI absorption	May
Aadarsh Pathak	Student - PhD	Cambridge, USA	Analytical predictions for emission-line galaxy properties in the JWST-FRESCO survey	June
Aman Khalid	Student - PhD	Sydney, Australia	The Rubin Observatory in Simulated Universes: TIdal Features	June
Ravi Jaiswar	Student - PhD	Sydney,Australia	Unwrapping the Epoch of Reionisation through Mimic Galaxies at Cosmic Noon	June

Ryan Bagge	Student - PhD	Lyon, France	The MAGPI Survey: The chicken or the egg, velocity disturbances causing feedback, or stellar feedback causing velocity disturbances.	June
Antonia Fernandez Figueroa	Student - PhD	Hobart, Australia	The circumgalactic medium of galaxy pairs	June
Aadarsh Pathak	Student - PhD	Sydney, Australia	Analytical predictions for emission-line galaxy properties in the JWST-FRESCO survey	July
Balu Sreedhar	Student - PhD	Sydney, Australia	Constraining the astrophysics of the early Universe with 21-cm power spectra	July
Miftahul Hilmi	Student - PhD	Sydney, Australia	A novel analysis of contamination in Lyman break galaxy samples based on spatial cross-correlation with intermediate-redshift galaxies	July
Alma Sebastian	Student - PhD	Macquarie Park, Australia	The evolution of MgII, CII and OI across 2<z<6 using XQR-30	July
Katherine Harborne	Affiliate	Krakow, Poland	From particles to pixels: Connecting observational surveys and cosmological surveys from the beginning with MAGPI	July
Aman Chokshi	Student - PhD	Perth, Australia	Rotation Measure Leakage and MWA Beam Models	July
Giulia Santucci	Affiliate	Krakow, Poland	Connecting the stellar orbital distributions of galaxies with their evolution history	July
Zara Osborn	Student - PhD	Sesto, Italy	Chemical Abundance Anomalies from Binary AGB Stars	July
Tomas Rutherford	Student - PhD	Sydney, Australia	Using Streams and Shells to Trace the Dynamical Evolution of Massive Galaxies	July
Chien-Chang Ho	Student - PhD	Sydney, Country	Future Constraints on Dark Matter with Gravitationally Lensed Fast Radio Bursts Detected by BURSTT' ACAMAR9 Workshop	July
Bronwyn Reichardt Chu	Affiliate	Sydney, Australia	DUVET: How do outflows affect star formation?	July
Miftahul Hilmi	Student - PhD	Koriyama, Japan	A novel analysis of contamination in Lyman break galaxy samples based on spatial cross-correlation with intermediate-redshift galaxies	August
Alma Sebastian	Student - PhD	Perth, Australia	The Chemical Enrichment of early Universe towards the tail end of Epoch of Reionisation using XQR-30	August
Andrew Battisti	Affiliate	Busan, South Korea	The average dust attenuation curve at z~1.3	August
Henry Zovaro	Associate Investigator (AI)	Sedona, Arizona	Resolving galaxies at the peak of cosmic star formation with GMTIFS	August
Tomas Rutherford	Student - PhD	Canberra, Australia	Identifying tidal features in galaxy populations with SAMI - What role do mergers play in the formation of slow rotators?	September
Antonia Fernandez Figueroa	Student - PhD	Los Angeles, USA	The circumgalactic medium of galaxy pairs	September
Yifan Mai	Student - PhD	Sydney, Australia	Drivers of gas velocity dispersion of SAMI, MAGPI and KROSS galaxies	October
Sujeeporn Tuntipong	Student - PhD	Sydney, Australia	Milk Way Analogues: finding siblings of the Milky Way	November
Aman Chokshi	Student - PhD	Amsterdam, Netherlands	The Necessity of Validated Beam Models for Epoch of Reionisation Science	December
Tomas Rutherford	Student - PhD	Wollongong, Australia	Identifying merger features in galaxy populations with SAMI - What role do mergers play in the formation pathway of slow rotators?	December

PROFESSIONAL ORGANISATION BRIEFINGS

Cathryn Trott	Chief Investigator (CI)	Perth, Australia	Introduction to Interferometry	February
Karen Lee-Waddell	Associate Investigator (AI)	Victoria, Canada	Australian SKA Regional Centre (AusSRC)	April
Emily Kerrison	Student - PhD	Oxford, UK	Hunting down supermassive black holes, the Bayesian way	August
Aditya J N H S	Research Staff	Pune, India	Proposal review: A pilot study of ionospheric disturbances in the Northern and Southern hemispheres with the uGMRT using sub-array configuration	August

PUBLIC/OUTREACH TALKS

Bi-Qing For	Associate Investigator (AI)	Pekan Nanas, Malaysia	N/A	January
Cathryn Trott	Chief Investigator (CI)	Perth, Australia	Science with the SKA	February
Ashley Ruiter	Associate Investigator (AI)	The Kingston Hotel	The birth and (sometimes untimely) death of stars	March
Sarah Martell	Chief Investigator (CI)	Sydney, Australia	Mysteries of the Universe	March
Kathryn Grasha	Fellow	Canberra, Australia	All the light we see in the sky are stars like our Sun	April
Emma Ryan-Weber	Chief Investigator (CI)	Ballarat, Australia	Meet an Astrophysicist	April
Karen Lee-Waddell	Associate Investigator (AI)	Cape Town, South Africa	Dr Karen Lee-Waddell	May
Sarah Sweet	Affiliate	Brisbane, Australia	Arthur Page Memorial Lecture	May
Taissa Danilovich	Associate Investigator (AI)	Melbourne, Australia	Observing the Deaths of Stars like the Sun	May

Rebecca Davies	Research Staff	Melbourne, Australia	Tracing 13 billion years of history by the light of ancient quasars	May
Adam Batten	Affiliate	Melbourne, Australia	A How To Guide To Simulating the Universe	May
Karen Lee-Waddell	Associate Investigator (AI)	SpaceConnectHQ podcast	ASKAP breakthrough on mysterious fast radio bursts	June
Rebecca McElroy	Affiliate	Brisbane, Australia	How galaxies collide	July
Deanne Fisher	Chief Investigator (CI)	Melbourne, VIC	QueersInScience-Fiction	July
Alma Sebastian	Student - PhD	Gembrook Recreation Reserve, Australia	N/A	August
Nandini Sahu	Research Staff	Green Point Observatory, Oyster Bay, Sutherland astronomical society	From Scaling Black Holes to Measuring Dark Matter in Galaxies	August
Caroline Foster	Associate Investigator (AI)	Marrickville Public Library, NSW, Australia	Asteroids, Alternate Realities and Black Holes.	August
Rebecca McElroy	Affiliate	Brisbane, Australia	How galaxies collide	August
Taissa Danilovich	Associate Investigator (AI)	Ballarat, Australia	Molecules in Space	August
Madusha Gunawardhana	Research Staff	Coonabarabran, Australia	In person brief talks related to the AAT and various instruments it hosts during the open day	September
Jonathan Bland-Hawthorn	Chief Investigator (CI)	3 locations - Chatswood, Blue Mountains, University of Sydney Main Hall	Galileo, Bach and the Western view of the Heavens	September
Antonia Fernandez Figueroa	Student - PhD	Melbourne, Australia	All the opportunities astronomy has given me	September
Lara Sharp	Professional Staff	Canberra, Australia	STARS PD: Using filters	September
Kathryn Grasha	Fellow	Canberra, Australia	We are all made of stars	September
Karen Lee-Waddell	Associate Investigator (AI)	Sydney, Australia	BETTER, FASTER, FURTHER: COSMIC ORIGINS & THE SKAO	October
Ashley Ruiter	Associate Investigator (AI)	UNSW Canberra Officer's Mess	Double white dwarf mergers: things they might (and probably do) make	October
Ridhima Nunhokee	Research Staff	Mauritius	Development of the Space Sector in Mauritius	October
Sven Buder	Fellow	Siding Spring Observatory, Coonabarabran, Australia	The History of the Milky Way	October
Sven Buder	Fellow	Sidin Spring Observatory, Coonabarabran, Australia	Stellar Rainbows	October
Ravi Jaiswar	Student - PhD	Perth,Australia	How Galaxies Shaped the Universe	November

SCHOOL TALKS

Stefania Barsanti	Research Staff	Sydney, Australia	Galaxy kinematics in the Cosmic Web	February
Jesse van de Sande	Associate Investigator (AI)	Balkbrug, The Netherlands	Exploring the Universe	February
Sarah Brough	Affiliate	Mosman, Australia	Space!	February
Karen Lee-Waddell	Associate Investigator (AI)	Perth, Australia	The Sun	April
Ravi Jaiswar	Student - PhD	Broome/Kimberly ,Australia	Went to schools as a part of ICRAR outreach to give lessons on astronomy to public schools	April
Karen Lee-Waddell	Associate Investigator (AI)	Perth, Australia	Meet Dr Karen	June
Caroline Foster	Associate Investigator (AI)	Marist Sisters College, Woolwich, Australia	A journey to the galaxies	June
Alma Sebastian	Student - PhD	Ballarat, Australia	My journey so far	June
Emma Ryan-Weber	Chief Investigator (CI)	For Loreto College Ballarat, at Swinburne University.	Careers in Astrophysics	June
Adam Batten	Affiliate	Geelong, Australia	About the Sun	July
Karen Lee-Waddell	Associate Investigator (AI)	Perth, Australia	Aboriginal Astronomy	August
Ashley Ruiter	Associate Investigator (AI)	Ainslie Primary (Canberra)	Where does all this stuff around me (including me!) actually come from?	August
Karen Lee-Waddell	Associate Investigator (AI)	Perth, Australia	Aboriginal Astronomy	September
Karen Lee-Waddell	Associate Investigator (AI)	Perth, Australia	Meet Dr Karen	September
Sarah Sweet	Affiliate	Logan Village, Australia	Things I Love About the Night Sky	September
Emma Ryan-Weber	Chief Investigator (CI)	Ballarat, Australia	Key note presentation to Graduating class and stakeholders	November
Sarah Sweet	Affiliate	Adelaide, Australia	Interview with an astrophysicist	November
Sarah Sweet	Affiliate	Gold Coast, Australia	A Blessed Planet	November

Note - Education and Outreach Affiliate Dr Brad Tucker did 1,055 Radio and TV interviews including Sky news, Channel 7 Sunrise and Evening news, WIN news, ABC Breakfast, ABC 24 and various radio stations across Australia. He also gave 166 Public talks which included School groups.

Image: AI Andrew Battisti gives his sparkler talk at the ASTRO 3D Science Meeting. Photo: Cristy Roberts

ASTRO 3D MEMBER VISITS TO INTERNATIONAL INSTITUTIONS AND ASTRONOMY FACILITIES 2023

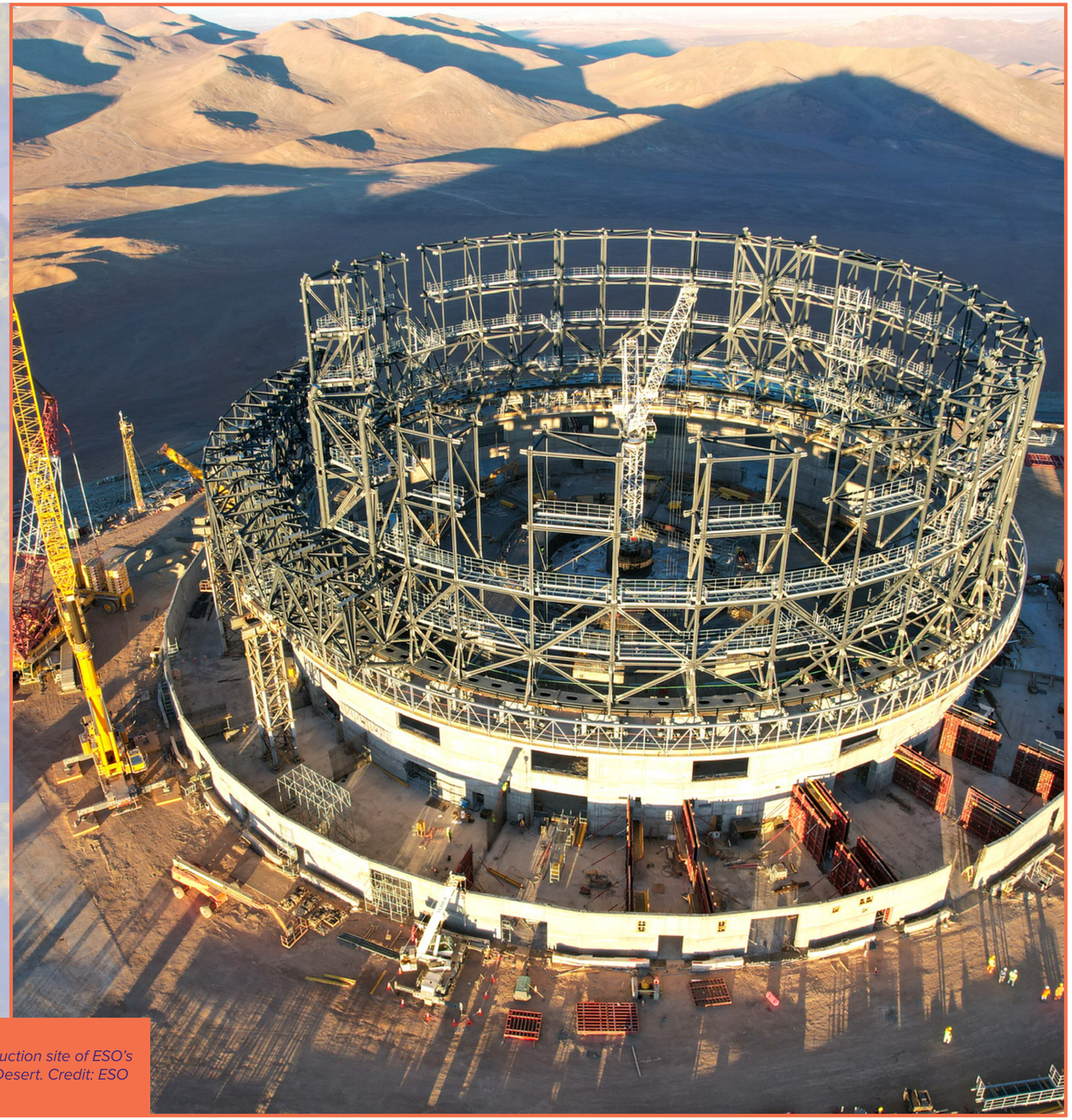
Image: PhD student Luisa Buzzo in front of the Keck Telescope in Hawaii. Photo: supplied.

NAME	MEMBERSHIP STATUS	NAME OF INSTITUTION/ FACILITY	LOCATION	MONTH
Kim-Vy Tran	Affiliate	Center for Astrophysics | Harvard Smithsonian	Cambridge, Massachusetts, USA	January
Tania Barone	Research Staff	Keck Telescopes	Mauna Kea, Hawaii	January
Hasti Nateghi	Student - PhD	Keck Observatory	Hawaii, USA	January
Kim-Vy Tran	Affiliate	Yale - National University of Singapore	Singapore	February
Jeff Cooke	Associate Investigator (AI)	W.M. Keck Observatory NAOJ Subaru University of California, Santa Cruz University of Toronto University of Illinois, Urbana Champaign San Diego State University Caltech W.M. Keck Observatory	Waimea, Hawaii, USA Hilo, Hawaii, USA Santa Cruz, USA Toronto, Canada Urbana/Champaign, Illinois, USA San Diego, California, USA Pasadena, California, USA Waimea, Hawaii, USA	February
Hasti Nateghi	Student - PhD	New Mexico State University	Las Cruces, New Mexico State, USA	February
Jeff Cooke	Associate Investigator (AI)	W M Keck Observatory NAOJ, Subaru Headquarters University of California, Santa Cruz University of Toronto University of Illinois California Institute of Technology (Caltech) San Diego State University University of French Polynesia	Maunakea, Hawaii, USA Hilo, Hawaii, USA Santa Cruz, California, USA Toronto, Ontario, Canada Champaign-Urbana, Illinois, USA Pasadena, California, USA San Diego, California, USA Papeete, Tahiti	February
Zixian Wang	Alumni	University of Utah	Salt Lake City, UT, US	March
Kim-Vy Tran	Affiliate	University of British Columbia	Vancouver, Canada	March
Michael Hayden	Associate Investigator (AI)	Biosphere 2	Tucson, Arizona, USA	March
Ioana Ciuca	Research Staff	Kavli Institute for Theoretical Physics	Santa Barbara, California, United States	March
Takafumi Tsukui	Research Staff	National Astronomical Observatory of Japan East-Asian ALMA Regional Center (EA-ARC)	Tokyo, Japan Tokyo, Japan	March
Yuxiang Qin	Research Staff	Scuola Normale Superiore	Pisa, Italy	March
Yuxiang Qin	Research Staff	University of Copenhagen	Copenhagen, Denmark	March
Zixian Wang	Alumni	Space Telescope Science Institute	Baltimore, MD, US	April
Jesse van de Sande	Associate Investigator (AI)	University of California Davis	Davis, US	April

Jesse van de Sande	Associate Investigator (AI)	University of California Berkeley	Berkeley, US	April
Ioana Ciuca	Research Staff	Flatiron Institute	New York, New York, United States	April
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Laboratoire d'Astrophysique	Marseille, France	April
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Fresnel Institute	Marseille, France	April
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Palais de Pharo	Marseille, France	April
Zixian Wang	Alumni	Space Telescope Science Institute	Baltimore	April
Aditya J N H S	Research Staff	ATCA	Narrabri, Australia	April
Karen Lee-Waddell	Associate Investigator (AI)	Canadian Astronomy Data Centre - CADC & NRC	Victoria, Canada	April
Kristan Boyett	Fellow	University of Oxford	Oxford, UK	May
Jaiden Cook	Student - PhD	The University of Washington, Trottier Space Institute, McGill University, Kapteyn Institute, University of Groningen	Seattle, United States of America, Montreal, Canada, Groningen, Netherlands	May
Michael Hayden	Associate Investigator (AI)	Stockholm University	Stockholm, Sweden	May
Michael Hayden	Associate Investigator (AI)	University of Uppsala	Uppsala, Sweden	May
Michael Hayden	Associate Investigator (AI)	University of Sussex	Brighton, UK	May
Kathryn Grasha	Fellow	Center for Astrophysics, Harvard University	Boston, USA	May
Michelle Cluver	Associate Investigator (AI)	Oxford University	Oxford, United Kingdom	May
Jesse van de Sande	Associate Investigator (AI)	Kapteyn Astronomical Institute, Groningen University Leiden Observatory, Leiden University	Groningen, The Netherlands Leiden, The Netherlands	June
Yuxiang Qin	Research Staff	Scuola Normale Superiore	Pisa Italy	June
Yuxiang Qin	Research Staff	Scuola Normale Superiore	Pisa, Italy	June
Nandini Sahu	Research Staff	Max Planck Institute for Astrophysics	Munich, Germany	June
Stefania Barsanti	Research Staff	University of Durham University of Nottingham University of Cambridge University of Oxford Max Planck Institute for Extraterrestrial Physics	Durham,UK Nottingham,UK Cambridge, UK Oxford, UK Munich, Germany	June
Deanne Fisher	Chief Investigator (CI)	Max Plank Institute for Astrophysics (MPA)	Garching, Germany	June
Deanne Fisher	Chief Investigator (CI)	Kapteyn Institute	Groningen, Netherlands	June
Amanda Karakas	Chief Investigator (CI)	University of Padova	Padova, Italy	June
Caroline Foster	Associate Investigator (AI)	LMU Munich University of Hertfordshire Oxford University University of Cambridge	Munich, Gemany Hartfield, UK Oxford, UK Cambridge, UK	June
Ryan Bagge	Student - PhD	École Supérieure de Chimie Physique Électronique de Lyon	Lyon, France	June
Balu Sreedhar	Student - PhD	Scuola normale superiore Cosmic Dawn CCA, Flatiron	Pisa, Italy Copenhagen, Denmark New York, USA	June
Barbara Mazzilli Ciraulo	Research Staff	European ALMA Regional Centre (ARC) at IRAM	Grenoble, France	July
Thomas Nordlander	Associate Investigator (AI)	Uppsala University Stockholm University MIAPbP	Uppsala, Sweden Stockholm, Sweden Garching Munich, Germany	July
Giulia Santucci	Affiliate	University of Vienna	Vienna, Austria	July
Adam Batten	Affiliate	Munich Institute for Astro- and Particle Physics	Munich, Germany	July
Emily Kerrison	Student - PhD	Max Planck Institute for Extraterrestrial Physics ESO ASTRON University of Leiden Imperial College London Oxford University	Garching, Germany Garching, Germany Dwingeloo, Netherlands Leiden, Netherlands London, UK Oxford, UK	July
Luisa Buzzo	Student - PhD	University of Innsbruck	Innsbruck, Austria	July
Thomas Nordlander	Associate Investigator (AI)	Uppsala University Stockholm University MIAPbP	Uppsala, Sweden Stockholm, Sweden Munich, Germany	July
Luca Casagrande	Associate Investigator (AI)	Munich Institute for Astro-, Particle and BioPhysics	Garching, Germany	August
Amanda Karakas	Chief Investigator (CI)	Munich Institute for Astro, Particle and biophysics	Munich, Germany	August
Madeline Howell	Student - PhD	Aarhus University Konkoly Observatory	Aarhus, Denmark Budapest, Hungary	August
Xi Wang	Student - PhD	Munich Institute for Astro-, Particle and BioPhysics Uppsala University Lund University Stockholm University Arcetri Observatory	Garching, Germany Uppsala, Sweden Lund, Sweden Stockholm, Sweden Florence, Italy	August
Katherine Harborne	Affiliate	Interdisciplinary Center for Scientific Computing (IWR)	Heidelberg, Germany	August
Miftahul Hilmi	Student - PhD	University of Tsukuba Waseda University Institute for Cosmic Ray Research, University of Tokyo National Astronomical Observatory of Japan	Tsukuba, Japan Tokyo, Japan Kashiwa, Japan Mitaka, Japan	August
Simon Weng	Student - PhD	European Southern Observatory	Munich, Germany	September
Amanda Karakas	Chief Investigator (CI)	Institute for Basic Science	Daejeon, Korea	September
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Harvard University MIT	Boston, USA	September
Sam Vaughan	Research Staff	Oxford University	Oxford, United Kingdom	September
Sam Vaughan	Research Staff	Centre for Computational Astrophysics	New York, USA	September
Jonathan Bland-Hawthorn	Chief Investigator (CI)	Paris Observatory Institut d'Astrophysique, Paris Meudon Observatory, Paris	London, UK Paris, France	October

Visits to International Institutions and Telescope Facilities

Robert Adriel Mostoghiu Paun	Affiliate	Universidad Autonoma de Madrid	Madrid, Spain	October
Jesse van de Sande	Associate Investigator (AI)	l'Observatoire de Paris	Paris, France	October
Ryan Bagge	Student - PhD	Kvali Institute for Cosmology, Cambridge, England	Cambridge, England	October
Michael Hayden	Associate Investigator (AI)	Paris Observatory	Paris, France	October
Luisa Buzzo	Student - PhD	Keck Telescope	Hawaii, USA	November
Sarah Brough	Affiliate	INAF Capodimonte Astronomical Observatory, Naples	Naples, Italy	November
Randall Wayth	Associate Investigator (AI)	SKA-Low telescope construction site	Boolardy, Australia	November
Jaiden Cook	Student - PhD	University of North Carolina, Asheville campus	Asheville, North Carolina, United States of America	November
Aman Chokshi	Student - PhD	University of Manchester Paris Observatory - LERMA Institut d'Astrophysique Spatiale - Paris-Saclay Orsay École Polytechnique Fédérale de Lausanne (EPFL) Kapteyn Astronomical Institute - University of Groningen	Manchester - UK Paris - France Paris-Saclay - France Lausanne - Switzerland Groningen - Netherlands	November
Antonia Fernandez Figueroa	Student - PhD	W. M. Keck Observatory	Hawaii, USA	November
Benjamin Metha	Student - Masters	University of California Los Angeles	Los Angeles, United States of America	December
Michelle Cluver	Associate Investigator (AI)	South African Astronomical Observatory	Cape Town, South Africa	December



This image, taken in late June 2023, shows a drone shot of the construction site of ESO's Extremely Large Telescope at Cerro Armazones, in Chile's Atacama Desert. Credit: ESO

ASTRO 3D PUBLICATIONS 2023

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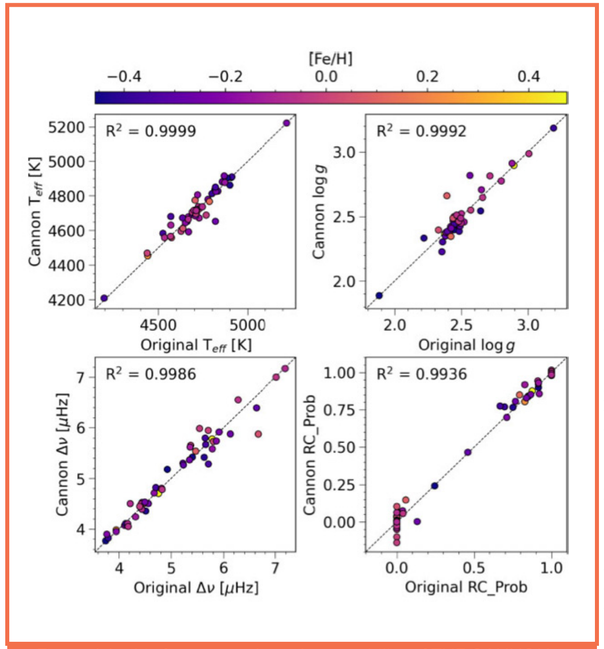

Figure 1: In this figure, we show the capability of THE CANNON to predict the labels of the model. The x -axis of each plot illustrates the kno wn v alues of each parameter and the y -axis shows the values predicted by THE CANNON . The dashed diagonal lines show the one-to-one relationship between the known and predicted values. Here, we also include the R 2 value of the one-to-one fit with the data. Even with a small data set of 49 stars, our model is able to predict the parameters we train the model on with decent accuracy (Banks, K.A et al. MNRAS 523, L80)

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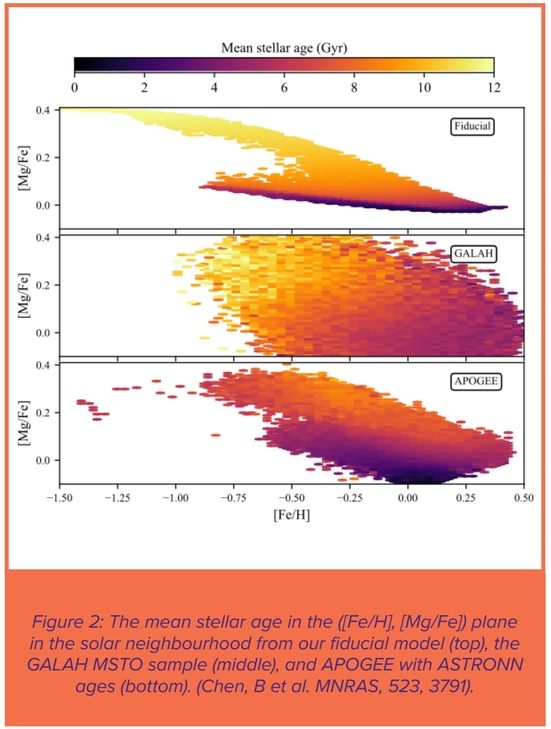

Figure 2: The mean stellar age in the ([Fe/H], [Mg/Fe]) plane in the solar neighbourhood from our fiducial model (top), the GALAH MSTO sample (middle), and APOGEE with ASTRONN ages (bottom). (Chen, B et al. MNRAS, 523, 3791).

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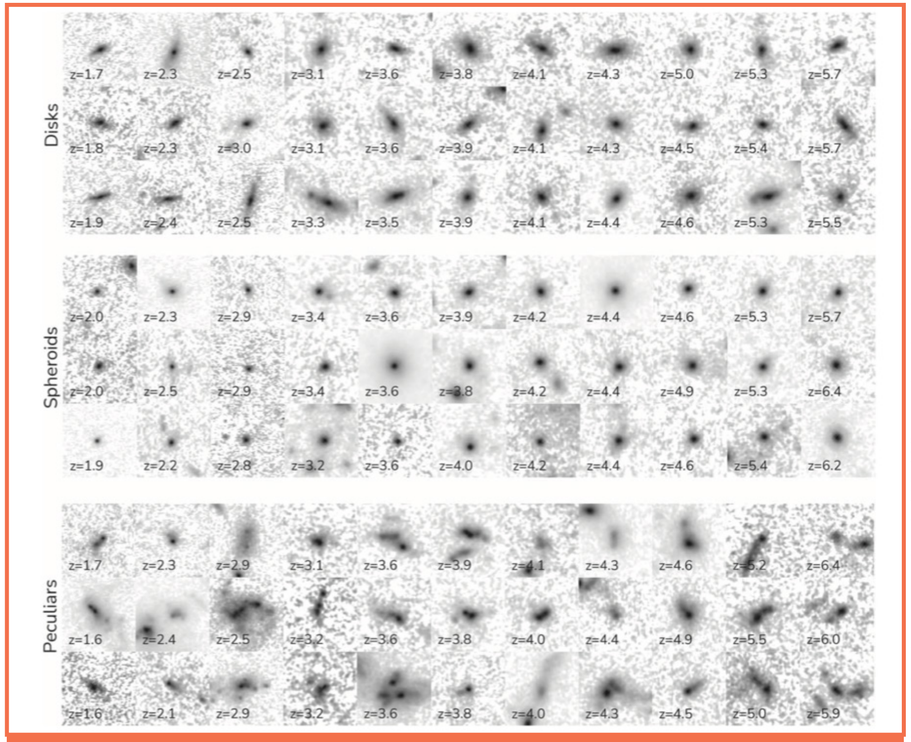

Figure 3: Rest-frame optical images for sources in our sample. The three panels show the three main classes disks, spheroids, and peculiars, respectively. Galaxies are ordered horizontally by redshift, from lowest on the left to highest on the right. Stamps are shown in square-root normalization. Redshifts are from Duncan et al. (2019) based on the CANDELS fields. (Ferreira, L. et al. The Astrophysical Journal, 955, 94)

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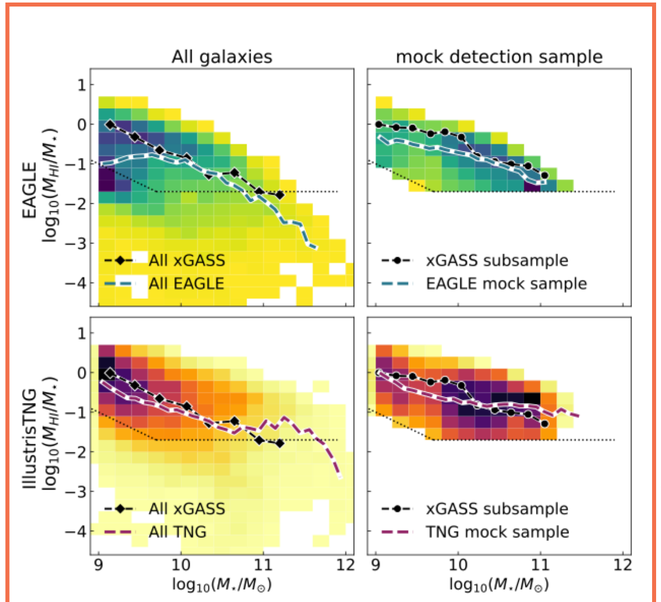

Figure 4: H I gas fraction versus stellar mass relation, for EAGLE (top row) and TNG (bottom row). The median relation from the full xGASS sample is shown as black diamonds for comparison (as published in Catinella et al. 2018), with the xGASS detection limit shown as dotted black lines. The left column shows all the galaxies in EAGLE and TNG in the background 2D histogram, with the median in bins of 0.1 de x o v erlaid as dashed blue/ magenta lines. In the right column, both the EAGLE and TNG mock detection samples are shown (see the text for this selection). Dark colours indicate regions of high density and vice versa. The xGASS subsample from Papers 1 and 2 is shown as black points. The 2D histogram colours of the left and right columns cannot be compared directly, as the right has been weighted to reco v er the xGASS stellar distribution, while the left has not.(Hardwick, J. A. et al. MNRAS 526, 808)

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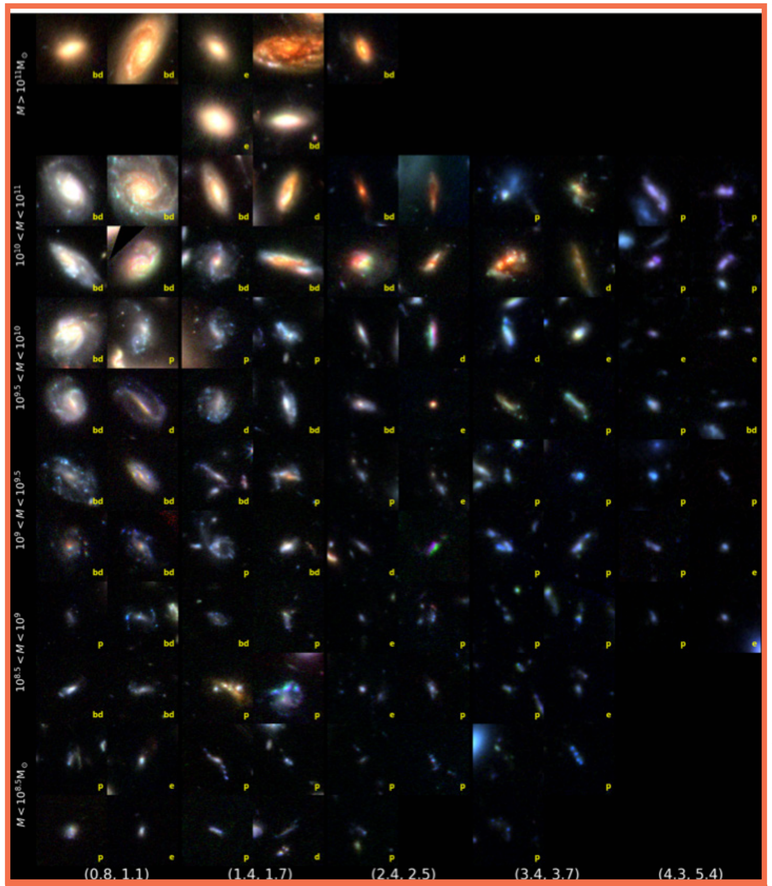

Figure 5: Rest-frame gri RGB images of selected sources organised by redshift bin (indicated at bottom, increasing left to right) and mass bin (indicated at left, decreasing top to bottom).Each postage stamp is 3".1 wide. Morphological classifications are indicated,where p= peculiar, e= elliptical, d=disk, and bd=bulge and disk. (Jacobs, C. et al. The Astrophysical Journal, 948, L13)

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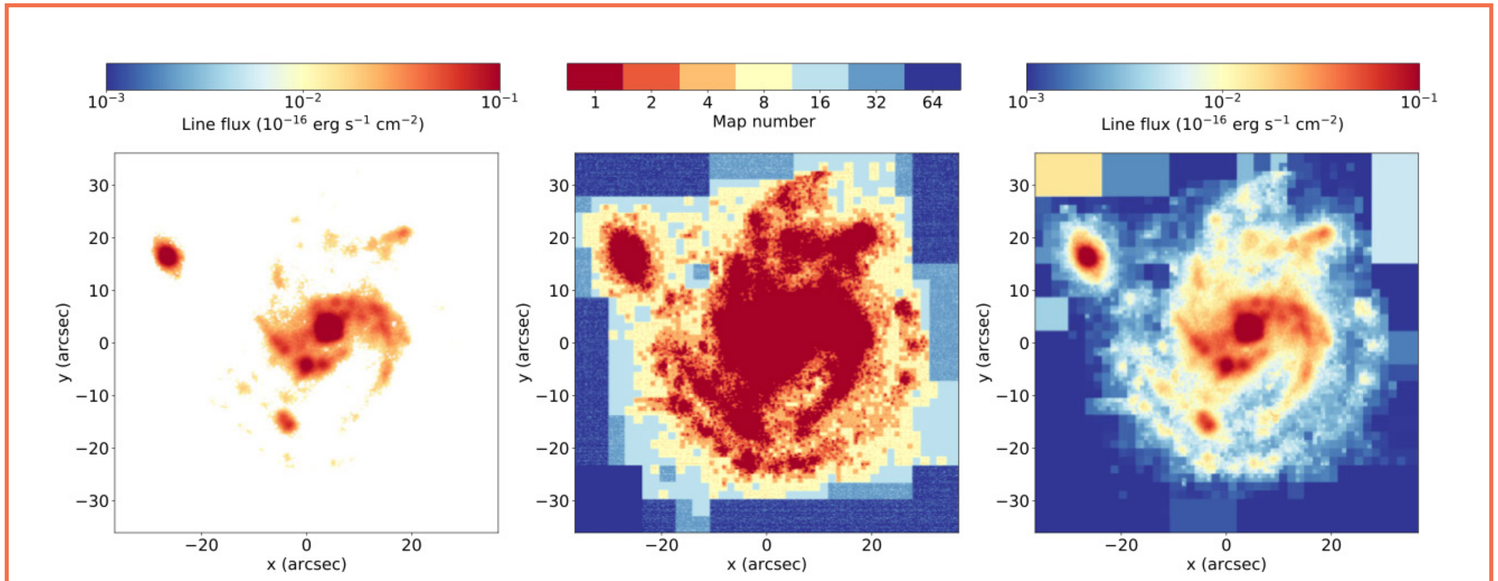

Figure 6: An illustration of adaptive binning reconstruction, using NGC 7674 (the host galaxy of SN2011hb) with a target S/N ratio of 3 as an example. The left-hand panel shows the original [S II] λ6731 map; blank areas show masked pixels with S/N < 3. The middle panel shows at which map (map N) each pixel reaches the target S/N. Note that red area in the middle panel corresponds exactly to the non-masked pixels in the left-hand panel, and these pixels will not be altered by adaptive binning because they are already above the target S/N. The right-hand panel shows the final, adaptively binned [S II] λ6731 map (Li, Z. et al. MNRAS, 518, 286.)

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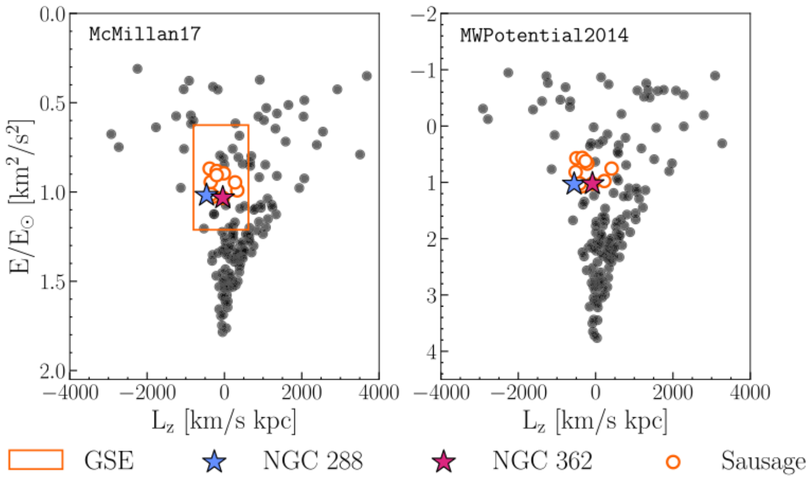

Figure 7: Ener gy (E in km 2 /s 2) scaled by solar energy versus angular momentum (L z in km/s2 kpc) for the majority of MW GCs calculated using the McMillan17 MW potential (as in the studies of Myeong et al. 2018 ; Massari et al. 2019), integrating for 2 Gyr (left). The extent of GSE in E versus L z as defined by Massari et al. (2019) is marked in orange, while the Sausage GCs identified by Myeong et al. (2018) are shown as the open orange circles. NGC 288 and NGC 362 are shown as the blue and pink stars, respectively. The same information is shown for GCs integrated in the MW Potential 2014 MW potential (right) (Monty, S. et al. MNRAS, 518, 965)

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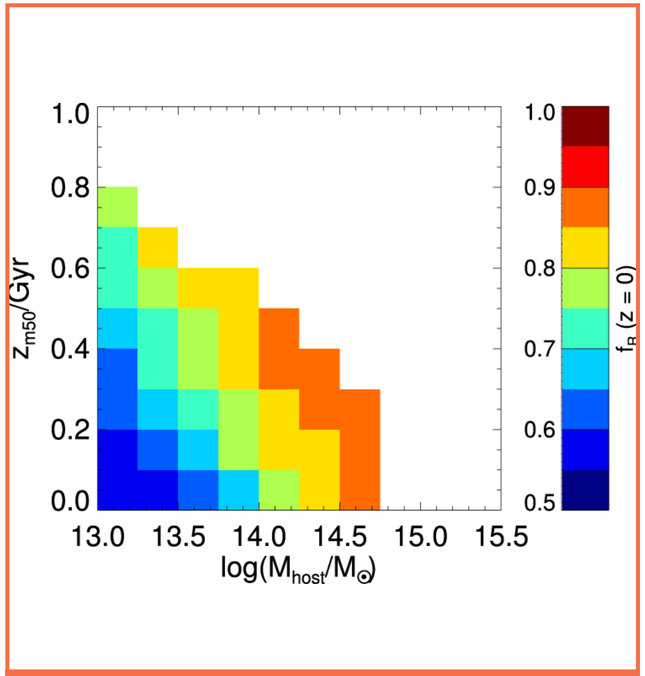

Figure 8: The 2D histogram of z_{m50} with M_{host}. The color bar represents f_R(z = 0). Pixels that have more than 10 data are used for statistical reliability. (Park, S.. et al. ApJ, 954,98)

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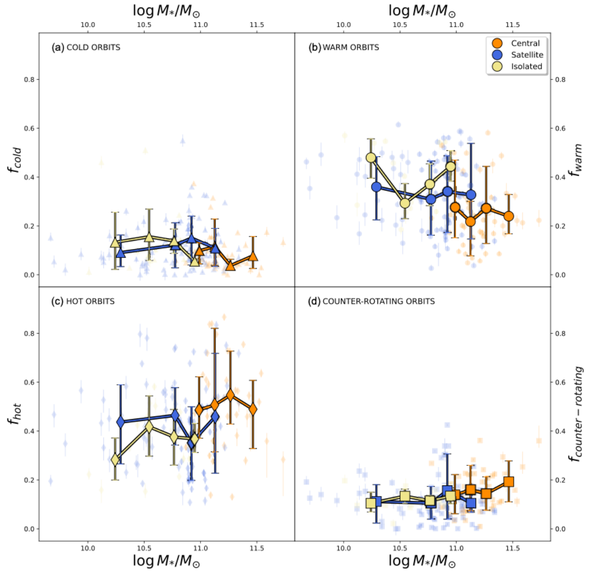

Figure 9: . Fractions of: (a) cold orbits, (b) warm orbits, (c) hot orbits, and (d) counter-rotating orbits as a function of stellar mass. Galaxies are classified into central (orange), satellite (blue), and isolated (yellow) galaxies. Each class is divided into four mass bins, with the bold points representing the mean values for each mass bin and the error bars indicate the 1 σ scatter around the mean value. In general, central, satellite, and isolated galaxies show similar trends for the fraction of orbits, with no significant difference, although at fixed stellar mass, central galaxies have the lowest fractions of warm orbits and the highest fractions of hot orbits. (Santucci, G. et al. MNRAS, 521, 2671.)

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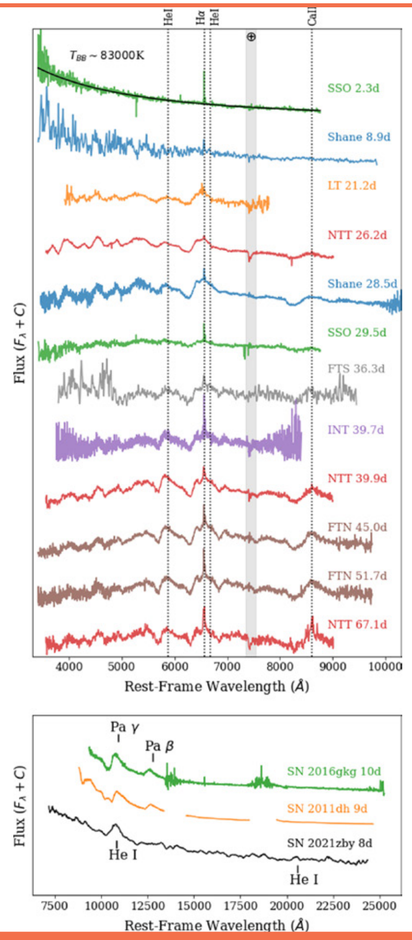

Figure 10: Top: optical spectral series of SN 2021zby with phases and telescopes labeled above. Spectra taken with different telescopes are plotted with different colors. Bottom: NIR spectrum of SN 2021zby taken by IRTF around the shock-cooling peak, in comparison with SN 2011dh (Ergon et al. 2015) and SN 2016gkg (Tartaglia et al. 2017) around a similar phase. The phases relative to the peak and relevant lines are labeled on the spectra. The telluric line in between 7170 and 7350 Å in the observer frame has been marked as the gray region. All the spectra have been normalized and shifted vertically for display purposes. (Wang, Q. et al. APJ 943, L15.)

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