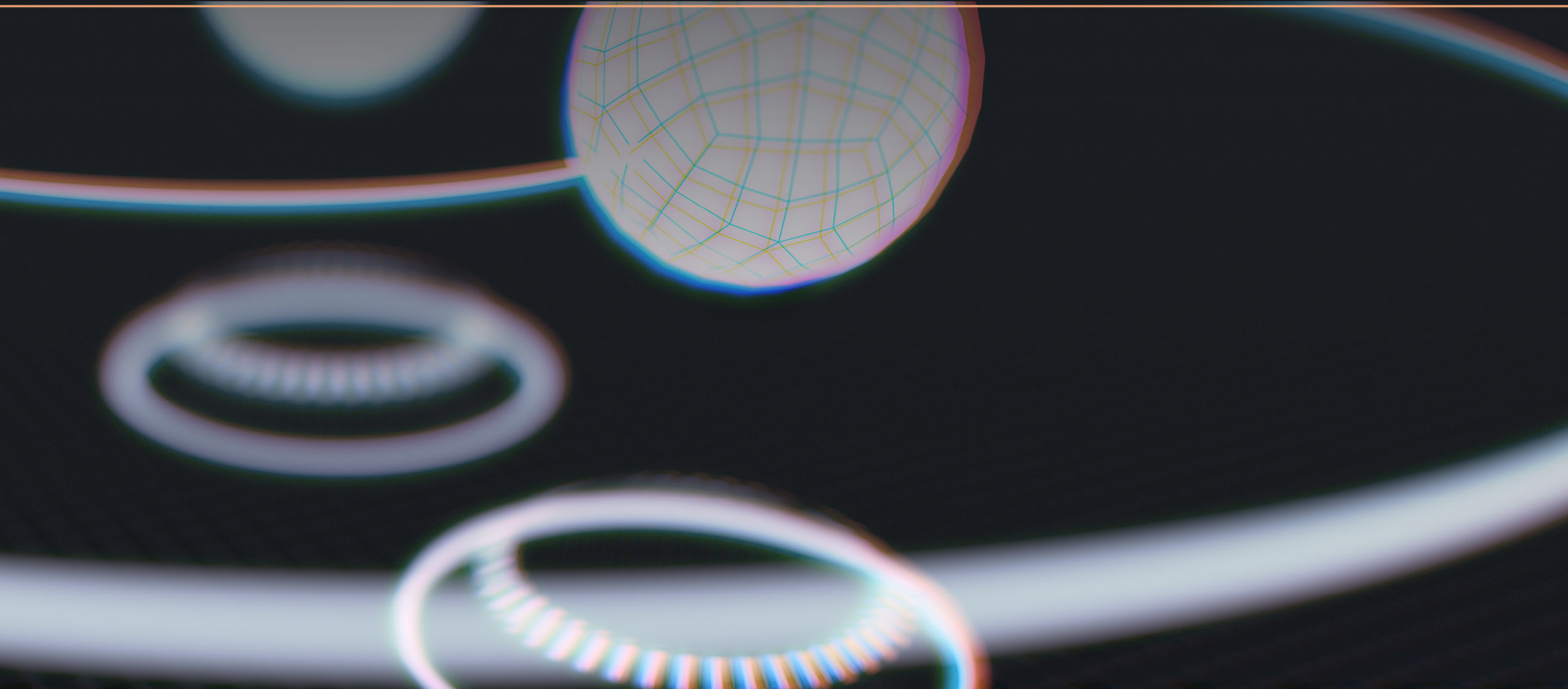
OzGrav

ARC Centre of Excellence for Gravitational Wave Discovery

INDUSTRY ENGAGEMENT SUCCESS STORIES



OUT OF THE LAB AND
INTO THE REAL WORLD

We work with our partners to ensure new gravitational wave technologies make it out of the lab and into the real world where they can make a lasting scientific, environmental and economic impact.

Background image by Carl Knox, OzGrav/Swinburne University

OUR STORY
... SO FAR

Gravitational wave research has a rich, innovative history with substantial commercial impact. OzGrav is committed to collaborating with the industry sector through research partnerships and engagement, as well as building deep alliances between companies and universities.

Contributing to three major national science and research priorities, including advanced manufacturing, soil and water, and environmental change, OzGrav has already developed numerous technology spin-offs with significant industry involvement.

OzGrav contributes integral technologies and research to many areas of industry and commercialisation including:

- Australian Defence
- Data science
- Earth & environmental science
- Advanced manufacturing

Icon credits: Freepik, Eucalyp and xnimrodx

...AND WE KEEP
GROWING

To continue our steady growth of collaborations, OzGrav encourages university nodes to establish commercial partners and joint appointments with research staff. The Centre employs a progressive IP utilisation strategy to support spin-off companies and Australian commercial partners, and empowers researchers to undertake research translation activities. The OzGrav internship programme also teaches PhD students about industry needs, the relevance of research to industry, and carves pathways for employment.

These industry engagement success stories highlight some of OzGrav's key industry collaborations that contribute invaluable science, technologies and transferable skills on a global scale.

Matthew Bailes
Director - OzGrav

M Bailes

GRAVITATIONAL WAVE TECHNOLOGY IN THE
DEFENCE INDUSTRY

Over several decades, defence and astronomy have been closely associated due to the advanced nature of optical and radio-frequency (RF) sensors used in astronomical observations, and the need for state-of-the-art technologies in defence.

Radar technology, for instance—which shaped the outcome of World War II—spawned the scientific field of radio astronomy, and some of the largest radio telescopes were subsequently built by ex-World War II radar engineers and scientists. The instrumentation and research infrastructure, such as advanced antenna feed designs and synthetic aperture astronomy, have also subsequently influenced defence capabilities.

Today, this association between astronomy and defence continues to be strong and beneficial with OzGrav Chief Investigators at the University of Melbourne (UoM) at the forefront.

The OzGrav team has developed spin-off technologies and expertise shaping defence capability, while enhancing astronomical discoveries. For example, over 40 years OzGrav investigators at UoM developed statistical signal processing algorithms to detect acoustic signals in the ocean, which have been further enhanced and used to detect pulsar signals and gravitational waves. There is now the potential to use these techniques to further enhance the acoustic detection of objects in the ocean—an important capability in the navigation of Australia's naval ships and submarines.

OzGrav Chief Investigators are playing a leading role in a new defence Multi-Function Aperture (MFA) program, developing next-generation phased array technology that will enable wideband simultaneous multi-function RF capability from a common aperture. The OzGrav team at UoM, in conjunction with other Australian universities, is supporting the first phase of this program under a multi-party collaborative agreement with the Defence Science Technology Group, funded by the Next Generation Technologies Fund.

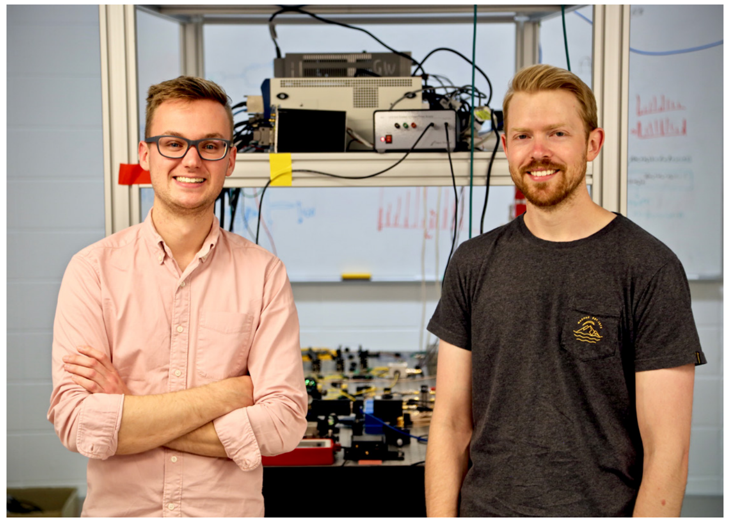
Astronomy is an excellent example of how big science and engineering, in the development of large telescopes and instruments, can drive industry and national capability, especially in areas such as defence.

The desire to progress our knowledge of the Universe can keep advancing defence technologies, such as surveillance and information systems. It's crucial that research funding is maintained to continue the development of large-scale research instruments and to engage scientists and engineers in research and industry as part of that endeavour.

Background image by Carl Knox, OzGrav/Swinburne University

OzGrav postdoctoral researcher Dr Lyle Roberts and EQUS PhD researcher James Spollard are developing a Light Detection and Ranging sensor (LiDAR) that measures not only how far away objects are, but also how fast they're moving. This work is being supported through the OzGrav Research Translation Seed Funding scheme open to OzGrav members.

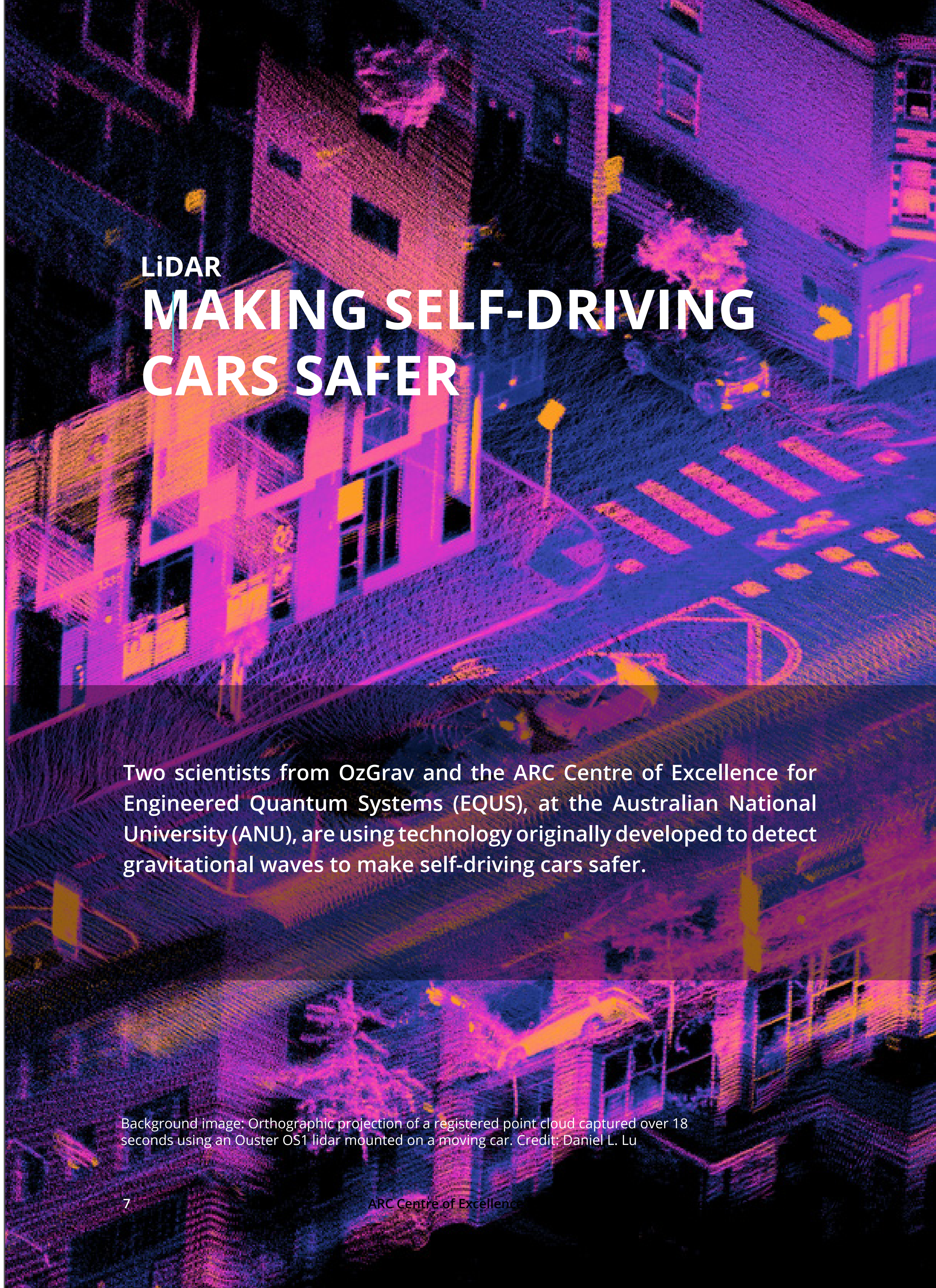
LiDAR is considered to be a crucial technology for self-driving vehicles as it provides highly detailed three-dimensional maps of the surrounding environment. It works by scanning a laser beam around the vehicle and analysing the light that reflects off the surrounding objects. Conventional LiDAR sensors typically only map the distance to surrounding objects; however, the LiDAR sensor developed by Roberts and Spollard measures many attributes of the light simultaneously, including frequency, which gives it the ability to measure distance as well as velocity.


EQUS PhD researcher James Spollard (left) and OzGrav postdoctoral researcher Dr Lyle Roberts (right)

By measuring velocity, Roberts and Spollard aim to make self-driving cars achieve super-human perception to navigate the road networks historically designed for humans, not robots. According to Spollard, 'in order for self-driving cars to be safer than human drivers, they require better-than-human perception. Autonomous vehicles are about 99% of the way there, but it's that last 1% that really matters.'

The sensor's ability to measure velocity could improve self-driving safety by prioritising objects based on movement. The human brain's visual cortex—which processes information produced by the eyes—is highly efficient at prioritising objects based on movement, Roberts explains. 'Objects that move within our field-of-view are more difficult to anticipate and therefore considered a higher priority than stationary objects. When driving, we tend to pay more attention to things that move because they are more likely to be hazardous.'

OzGrav Director Professor Matthew Bailes says: 'At OzGrav, we're really excited to support real-world applications of gravitational wave technology. This LiDAR technology is just one of many examples of cutting-edge gravitational wave research creating spin-off benefits to society and industry.'



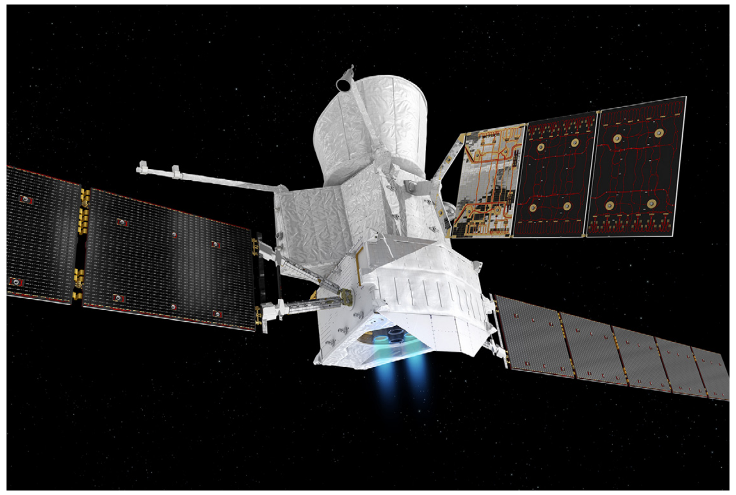
LiDAR

MAKING SELF-DRIVING CARS SAFER

Two scientists from OzGrav and the ARC Centre of Excellence for Engineered Quantum Systems (EQUS), at the Australian National University (ANU), are using technology originally developed to detect gravitational waves to make self-driving cars safer.

Background image: Orthographic projection of a registered point cloud captured over 18 seconds using an Ouster OS1 lidar mounted on a moving car. Credit: Daniel L. Lu

The powerful robotic Zadko Telescope, based at the Gingin Gravity Precinct in Yeal, Western Australia, is contracted by the European Space Agency (ESA) to observe asteroids—in particular Near Earth Objects (NEO's)—as part of the ESA's Space Situational Awareness program for the Southern Hemisphere.



An artist's impression of the ESA-JAXA BepiColombo spacecraft.
Credit: ESA/ATG medialab

The project includes OzGrav scientists from the University of Western Australia (UWA) and the Adam Mickiewicz University (AO AMU) in Poznań, Poland who use the telescope to survey the skies from a Perth vantage point.

The contract is part of a global strategy to provide advanced warning of future impacts of asteroids or comets. According to OzGrav Chief Investigator David Coward (UWA), the Zadko Telescope has the capability to monitor asteroids as far away from Earth as Mars and dangerous space rocks that may previously have been undetected near Earth. For example, in 2019 a 100-metre-wide asteroid was detected just hours before it came within 70,000 kilometres of Earth.

'There are thousands of rocks that orbit the Sun close to Earth and monitoring their activity is hugely important for the protection of our planet,' explains Associate Professor Coward. 'It's the smaller space rocks between 10 and 100 metres in diameter where current surveillance is missing. These rocks are often termed "city destroyers" and you need to have high precision telescopes, like the Zadko Telescope, to monitor these threats.'

The Zadko Telescope was also used to capture imagery of a space probe, named BepiColombo, passing Earth while on a journey to Mercury. Launched in 2018, BepiColumbo has since completed one and a half orbits around the Sun, travelling a distance of roughly 1.4 billion kilometres. The probe studies Mercury's magnetic field and its interaction with the solar wind, offering insight into how the Earth and solar system formed.

In addition to the collaboration with ESA, the UWA OzGrav node has partnerships with both commercial entities and international space agencies focussed on space situational awareness. These include the Polish Space Agency (POLSA), Ariane Group, Numerica Inc. and the United States Air Force Academy (USAFA).

The Zadko Telescope is supported by UWA's Office of Research and the Australian Research Council Centre of Excellence for Gravitational Wave Discovery (OzGrav), as well as forming a part of UWA's recently created International Space Centre.

THE ZADKO TELESCOPE

DEFENDING OUR EARTH

Background image: Zadko telescope. Photo supplied by UWA.

NEXT-GEN NAVIGATION TECHNOLOGY

A NEW $8.7 MILLION PROJECT

Background image sourced via Unsplash.

Australian scientists, including OzGrav researchers and industry partners, have joined forces to develop, design and manufacture the next-generation of optical gyroscopes for high-precision autonomous navigation in a new $8.7 million project.

The rapid and transformative development of autonomous vehicles in recent years has seen numerous technological breakthroughs. The deployment of ultra high-performance gyroscopes can enhance their performance in terms of safety and guidance. The use of ultra high-performance gyroscopes can already be found in a wide range of industries including infrastructure management, mining, space sciences, agriculture, and defence.

This new project is led by navigation systems manufacturer Advanced Navigation, with research partners The Australian National University (ANU), RMIT University, and commercial partner Corridor Insights. It will develop a new standard for optical gyroscopes, improving precision while reducing cost and size.

OzGrav Associate Investigator Jong Chow from ANU stated that the collaboration is a chance to bring together expertise from around the country: 'We have such a broad range of photonics expertise in Australia. This project brings it together, creating a nexus between universities, research and education, industry and government.'

The project has been supported through a $2.8 million Cooperative Research Centre Projects (CRCP) grant to Advanced Navigation. Chris Shaw, CEO of Advanced Navigation, said the project would translate ground-breaking foundational research at universities to commercialisation, demonstrating Australia's capability across the advanced manufacturing pipeline.

'This project will establish Australia as a leading manufacturer of high-performance, cost-effective navigation solutions,' Mr Shaw said. At the core of this endeavour is technology developed at the ANU Centre for Gravitational Astrophysics, OzGrav and Department of Quantum Science. The technique, called digital interferometry, combines advanced signal processing with precision optics to create ultra-high-resolution measurements using light.

While initially developed for measuring gravitational waves in spaceborne gravitational-wave detectors, the ANU team has adapted the technology to find a second home in optical gyroscopes. Commercial partner Corridor Insights will pilot the next-generation of optical gyroscope in autonomous infrastructure management, looking for early detection of defects and faults in Australia's rail network.

REVOLUTIONISING SPECIALISED

DEFENCE SYSTEMS, AIRBORNE METHANE DETECTORS AND WAVEFRONT SENSORS

Gravitational wave science has helped to boost technologies in many industries—OzGrav researchers at the University of Adelaide node have contributed their gravitational wave knowledge to the development of significant industry technology including specialised defence systems, airborne methane detectors and the Hartmann wavefront sensor.

Background image: Artist illustration by Carl Knox, OzGrav/Swinburne University

DEFENCE SYSTEMS

The quantum physics of non-classical states of light has improved the performance of second-generation gravitational-wave detectors, and OzGrav has played a significant part in this development. In recent years, other similar physics were claimed to significantly improve the performance of radar and lidar systems, birthing the concept of 'Quantum Radar'. Claims report that Quantum Radar could make stealth aircraft obsolete.

With funding from the Defence Science and Technology (DST) group, OzGrav researchers from the University of Adelaide have been assessing these claims based on their background in quantum limited interferometry. The OzGrav team, currently reporting to DST, has found that the claims of obsoleting stealth aircraft are highly unlikely, but Quantum Radar may benefit other niche applications.

AIRBORNE METHANE DETECTION

Natural gas is a significant source of energy for the modern world and is arguably the cleanest burning fossil fuel. However, methane, which is the dominant component of natural gas, has a carbon footprint 25 times higher than that of CO2. This means its advantages over coal are negated if less than 3% leaks from the point of extraction through the distribution network to its consumption by the end users. Aging infrastructure globally has meant that leaks in the distribution network are becoming increasingly likely as are leaks from abandoned well heads, which are costing the industry significantly to monitor.

The OzGrav-Adelaide team has been developing an airborne mapping system for methane borrowing laser technology from ground-based gravitational wave detectors. The recently developed laser-stabilisation techniques for the next generation of detectors can significantly increase the stability and robustness of the lasers used in the airborne methane detection and directly improve the sensitivity of the whole system.

HARTMANN WAVEFRONT SENSOR TECHNOLOGY

In collaboration with Lastek Pty Ltd—an Adelaide photonics company—and the assistance of a Photonics Catalyst Program grant from the South Australian Government, the OzGrav-Adelaide team investigated commercialising the Hartmann wavefront sensor technology, which was originally developed for the Advanced LIGO gravitational-wave detectors.

The technology is being used to develop an instrument that yields both the wavefront and intensity profile of an incident laser beam from a single measurement. While a profiler for visible and near-infrared wavelengths is currently being developed, the Hartmann IP can be used at any wavelength with a suitable pixelated camera. Such systems could be used for a wide range of laser applications, including remote sensing and Light Detection and Ranging (LiDAR), free space laser communications, advanced manufacturing and the development of new infrared laser sources.

SPIN-OFF COMPANY:
LIQUID INSTRUMENTS

Liquid Instruments (LI) Pty Ltd was founded by researchers from the gravitational-wave group, at the Australian National University (ANU), to commercialise advanced instrumentation technology derived from both ground and space-based gravitational-wave detectors. LI aims to disrupt the multi-billion dollar test and measurement industry with a new class of software-defined hardware. The company has raised $20M in Venture Capital funding and realised more than $5M in sales revenue. They now employ 42 staff in Australia and the US; many of them are former researchers and students who have transitioned to industry.

Moku:Lab in action: Max Schwenke (left) and Dr Sareh Rajabi (right)—both Liquid Instruments employees.

LI employs advanced digital signal processing to replace multiple pieces of conventional equipment at a fraction of the cost and with a drastically improved user experience. Their flagship product Moku:Lab is an all-in-one professional test and measurement device that provides the functionality of 12 instruments in one simple integrated unit. The device can switch between an oscilloscope, spectrum analyser, waveform generator, phasemeter, data logger, or lock-in amplifier (and many more) from a wireless, iPad-based interface.

In addition to enhancing their own research into gravitational-wave detection, it is now helping more than 1000 users worldwide in more than 30 countries. The company has identified three target markets: engineers and physicists in research and development divisions; industrial market segments such as aerospace and semiconductors in which engineers can use a Moku:Lab to develop and test new technologies and processes; and education, where LI CEO and former OzGrav Chief Investigator Daniel Shaddock (ANU) hopes to attract more students and enrich science, technology, engineering, and math (STEM) curricula around the world.

HEARING THE STARS:
DATA SONIFICATION IN ASTRONOMY

OzGrav student Garry Foran isn't the first blind astrophysicist but his work, with his supervisor OzGrav Chief Investigator, Jeff Cooke, is truly unique: developing novel tools that use sound to study distant galaxies and detect the fastest explosions in the Universe.

Image: Garry Foran and his guide dog, Trooper.
Credit: Swinburne University.

As part of OzGrav's research program called Deeper Wider Faster (DWF), these tools have not only made astronomy more inclusive for visually-impaired scientists, they've also improved the efficiency of data processing, and even helped sighted astronomers make new discoveries.

Cooke and Foran are currently working on using sonification in the DWF program which uses over 60 telescopes globally and in space to chase the fastest bursts in the Universe. Sonification is the use of human sound recognition to perceptualise data—a very new field in astronomy. When this massive DWF program is being coordinated and run, it generates simultaneous data from many of these telescopes.

One of the novel tools developed is called Star-Sound, which turns data points into different sounds and uses higher order harmonics to look for previously unseen connections and relationships. Higher-order harmonics are the same thing that help us discern if we hear a note by a flute or a trumpet. The note, frequency, duration and volume are all the same, but the human ear can instantly distinguish if the sound is a flute or a trumpet because different higher-order harmonics come off each instrument.

StarSound incorporates stereo sound to enable blind and visually-impaired people to hear and visualise the data plot—it integrates software that's been used in the music industry since the early 1970s to generate, manipulate and synthesise sound. The team aims to exploit the human brain to isolate and filter out desired sounds, otherwise known as the 'cocktail party effect': whereby someone can hear their name spoken softly in a noisy room because they are sensitised to certain sounds.

EYES ON THE SKY

DIAGNOSING EYE AND BRAIN DISEASE

Scientists at the Centre for Eye Research Australia (CERA) have teamed up with OzGrav at Swinburne University of Technology to better understand the mathematics behind diagnosing eye diseases. The team, led by ophthalmologist Dr Peter van Wijngaarden from CERA and OzGrav's Associate Investigator Christopher Fluke, applies the big data analysis used by astronomers in their study of the Universe, to the field of ophthalmology.

Using a new type of spectral imaging camera, CERA researchers apply these analysis principles to better understand the data generated, providing unique insights into diseases of the eye and brain, including Alzheimer's disease.

The collaboration was formed thanks to a generous donation from Australian entrepreneur Dr Steven Frisken, CEO of ophthalmic tech company, Cylite. He was one of four people jointly awarded the Prime Minister's Prize for Innovation in 2018. Dr Frisken and his colleague Dr Simon Poole received the prize for their work to transform optical telecommunication networks by developing the optical switching technologies that are needed for efficiently connecting the global internet.

Background image: MRI scan of brain sourced via Unsplash.

ADVANCED TECH FOR

AIRBORNE MINERAL EXPLORATION

OzGrav researchers at the University of Western Australia (UWA) and CGG Aviation have been awarded a new linkage grant to develop advanced aircraft transmitters and receivers for mineral exploration. The project aims to allow complex groundwater structures to be mapped more accurately and increase the depth to which conductive ore bodies can be detected. The new project follows UWA's recent success improving CGG's airborne gravity gradiometer. Using vibration isolation technology originally developed for gravitational wave detectors, the team has reduced the audible vibration level OF the instrument by a factor of 10.

Photo of the aircraft which will be involved in the new linkage project. Source: Airhistory.net

IMPROVING EARLY-WARNING SYSTEMS FOR

EARTHQUAKES

The Earthquake detection project, led by OzGrav Chief Investigator Dr Bram Slagmolen (Australian National University), aims to improve the advanced warning time for earthquake early-warning systems using sensor technology developed for gravitational wave detection. Dr Slagmolen and his team expect to utilise new technology to gain tens of extra seconds of warning, compared to current earthquake early-warning systems. This builds on their development of the TORsion PEndulum Dual Oscillator (TORPEDO)—designed to detect gravitational forces at low frequencies and from earthquakes. The team aims to implement this complementary technology into operational earthquake early warning systems, which could provide enormous benefit—even a few extra seconds cautioning dangerous seismic waves can save lives.

GRACE FOLLOW-ON MISSION:

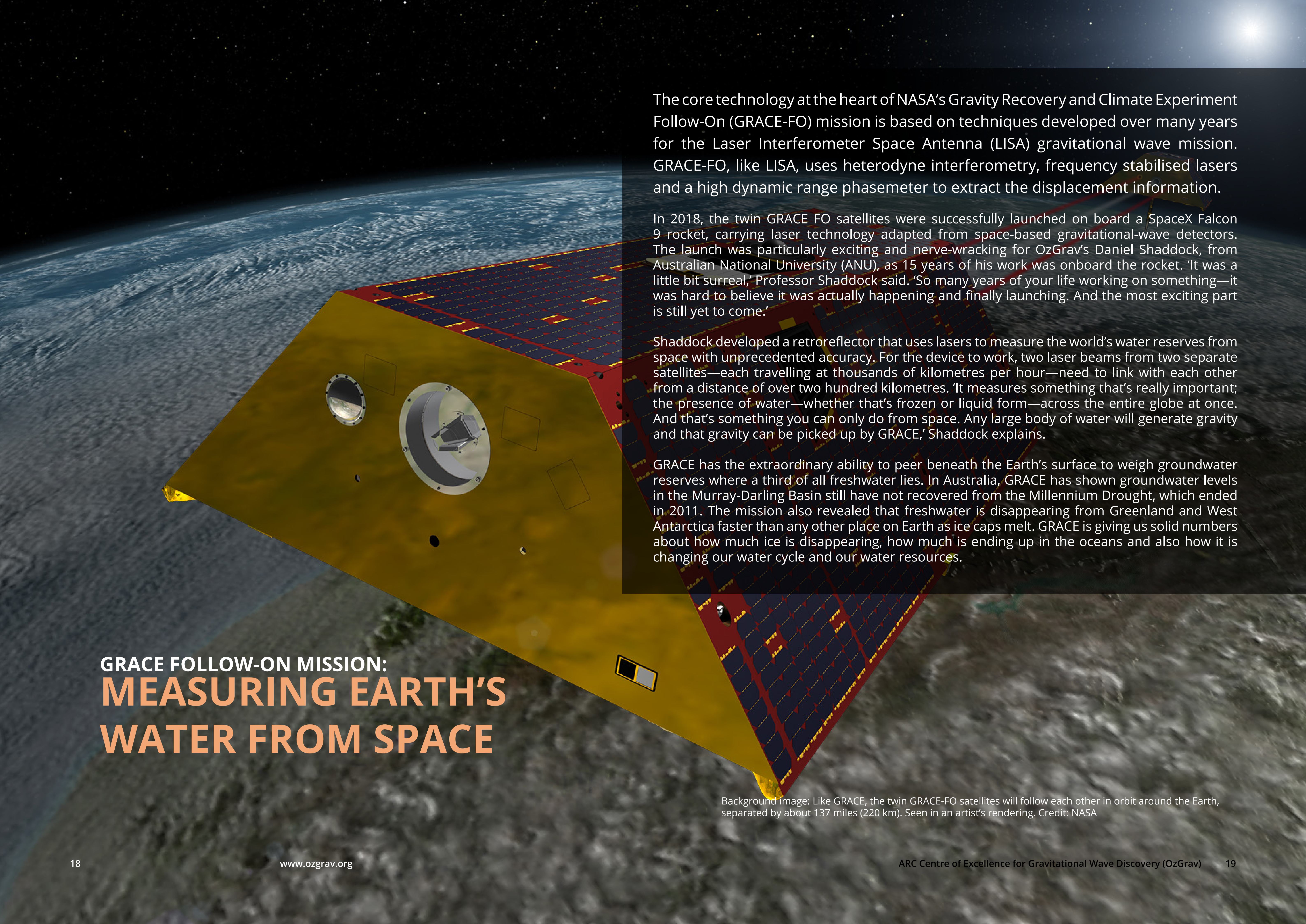
MEASURING EARTH'S WATER FROM SPACE

The core technology at the heart of NASA's Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission is based on techniques developed over many years for the Laser Interferometer Space Antenna (LISA) gravitational wave mission. GRACE-FO, like LISA, uses heterodyne interferometry, frequency stabilised lasers and a high dynamic range phasemeter to extract the displacement information.

In 2018, the twin GRACE FO satellites were successfully launched on board a SpaceX Falcon 9 rocket, carrying laser technology adapted from space-based gravitational-wave detectors. The launch was particularly exciting and nerve-wracking for OzGrav's Daniel Shaddock, from Australian National University (ANU), as 15 years of his work was onboard the rocket. 'It was a little bit surreal,' Professor Shaddock said. 'So many years of your life working on something—it was hard to believe it was actually happening and finally launching. And the most exciting part is still yet to come.'

Shaddock developed a retroreflector that uses lasers to measure the world's water reserves from space with unprecedented accuracy. For the device to work, two laser beams from two separate satellites—each travelling at thousands of kilometres per hour—need to link with each other from a distance of over two hundred kilometres. 'It measures something that's really important; the presence of water—whether that's frozen or liquid form—across the entire globe at once. And that's something you can only do from space. Any large body of water will generate gravity and that gravity can be picked up by GRACE,' Shaddock explains.

GRACE has the extraordinary ability to peer beneath the Earth's surface to weigh groundwater reserves where a third of all freshwater lies. In Australia, GRACE has shown groundwater levels in the Murray-Darling Basin still have not recovered from the Millennium Drought, which ended in 2011. The mission also revealed that freshwater is disappearing from Greenland and West Antarctica faster than any other place on Earth as ice caps melt. GRACE is giving us solid numbers about how much ice is disappearing, how much is ending up in the oceans and also how it is changing our water cycle and our water resources.



Background image: Like GRACE, the twin GRACE-FO satellites will follow each other in orbit around the Earth, separated by about 137 miles (220 km). Seen in an artist's rendering. Credit: NASA

CLOSING THE GENDER GAP IN STEM:

MISSION GRAVITY AND EINSTEIN-FIRST

Addressing gender inequities in science, technology, engineering and mathematics (STEM) is a key challenge not only for Australia, but for many countries across the world. In an effort to increase Australian students' uptake of STEM subjects, focussing on under-represented groups such as female students and regional schools, OzGrav's Education and Public Outreach (EPO) team has developed a world-first program within the Australian school curriculum called Mission Gravity.


OzGrav EPO Coordinator Jackie Bondell and students in the Mission Gravity program.
Credit: Carl Knox, OzGrav/Swinburne University

EPO Coordinator Jackie Bondell explains that Mission Gravity combines 'scientific modelling with interactive digital and virtual reality (VR) environments'. The program requires students to collaborate in teams, creating models of stellar evolution by collecting and analysing data from virtual trips to stars. The scientific tools facilitate students to make observations, interpret their results and create a model for the life of their star.

Research has shown that young learners are often engaged by digital and virtual experiences using computer programs, VR headsets and animation to understand complex ideas like gravitational waves. Key to Mission Gravity is the interactive software, developed by OzGrav's EPO Content Creator Mark Myers, that allows the students to virtually travel across the cosmos and observe stars.

'We've created a web browser-based version for teachers to use with the supplemental materials and delivered content,' adds Jackie. 'This content is now freely available to teachers via the OzGrav teacher's portal. This year we've also been promoting virtual school visits to reach rural Australian students, and we'll be seeking funding to support future face-to-face visits in rural areas.'

OzGrav scientists at the University of Western Australia have also developed a new school science program called Einstein-First to introduce Einsteinian physics in early schooling years. The gender-neutral program has already achieved fantastic and surprising results: girl students had equal or more positive attitudes towards physics compared to boy students. This new curriculum could help close the gender gap in science!

The Einstein-First project is part of OzGrav and includes local partners (the Gravity Discovery Centre, the Science Teachers' Association of Western Australia, the department of education and the Catholic department of education), national partners (Australian National University) and international partners. Using an activity-based approach, the project —initially designed to gauge if students could grasp the concepts—is not specifically gender-oriented, giving every child an equal opportunity to learn.

In their study, the OzGrav team found interesting gender results obtained from different interventions in Australia and Indonesia: regardless of academic stream, age group or culture, female students enter the program with substantially lower attitude scores towards physics than males; however, by the end of the program, both genders are equal in their attitude scores.

OzGrav researcher and first author of the study Dr Jyoti Kaur says: 'We had not set out to make the program gender-friendly, but the challenge of teaching a topic that many senior physicists had told us was not suitable for young people made us design classes that were highly interactive and full of group activities. We believe that this influenced the girls to respond so strongly—not because Einsteinian concepts are somehow more favoured by females. Whatever the cause, it was most exciting to realise that our curriculum could help to close the gender gap in science!'


Students participating in the Einstein-First program.
Image supplied by Dr Jyoti Kaur.

CAREER CASE STUDY:
DR DONALD PAYNE


Dr Donald Payne. Photo supplied.

In 2009, after completing his PhD with OzGrav Chief Investigator Andrew Melatos in astrophysics at the University of Melbourne, Dr Donald Payne co-founded a direct geothermal design & installation company called Direct Energy. Dr Payne experienced the ***coalface*** of various direct-use geothermal technologies (GSHPs & Ground Heat Exchangers) and their strengths and pitfalls. Recent industry undertakings include co-leading the Australian Geothermal Association (AGA) Census Special Interest Group (GSHPs) and driving an inquiry into the threat of Deep Well Direct Exchange (DWDX) geothermal systems. Industry interests have expanded to encompass integrated energy systems of which GSHPs are a component alongside solar thermal and Photo-Voltaic (PV), Battery Energy Storage Systems (BESS), wind power, and other complementary components.

Dr Payne graduated with degrees in physics and electrical engineering and subsequently a PhD in astrophysics, focusing on the evolution of magnetic fields around neutron stars in binaries and predicting their gravitational wave (GW) signatures. Follow-on research remains within the domain of OzGrav. Dr Payne then retained a position as honorary research fellow at the University of Melbourne until 2020.

Simultaneously Dr Payne serendipitously became involved in Australia's fledgling geothermal energy during a residential Ground Source Heat Pump (GSHP) installation in 2007. He was astounded by the paucity of Australian installation capability and the policy landscape with a Renewable Energy Target (RET) which excluded GSHPs yet included Air Source Heat Pumps (ASHPs).

This led to industry experiences including: co-chairing the Direct Use Sub-Committee of the Australian Geothermal Energy Association (AGEA); co-leading Technical Interest Group (TIG) 7 (Direct Use) of the Australian Geothermal Energy Association (AGEG); and co-writing the successful application for a $1.6 million Victorian Government Energy Technology Innovation Strategy (ETIS) Sustainable Energy Pilot Demonstration (SEPD) Program for monitoring direct geothermal installations throughout Victoria (delivered as a partnership between the University of Melbourne, Direct Energy, and GeoTech).

Background image by Carl Knox, OzGrav/Swinburne University

CAREER CASE STUDY:
DR CHRISTINE CHUNG

Dr Christine Chung is a research scientist in the Climate Research Section of the Australian Bureau of Meteorology. Her primary research interest is using climate models to simulate large-scale climate processes in the Pacific Ocean such as the El Nino Southern Oscillation: how they are affected by variability occurring in other parts of the world, and how they impact Australian climate. Dr Chung is also the Lead Chief Investigator for a project under the National Environmental Science Program's Earth Systems and Climate Change Hub.


Dr Christine Chung. Photo supplied.

Before joining the Bureau in 2011, Dr Chung completed her PhD at the School of Physics at the University of Melbourne ('Radio, X-ray, and Gravitational Wave Emission from Neutron Stars'). During this time she was a member of the Laser Interferometer Gravitational-wave Observatory (LIGO) consortium and contributed to a search for gravitational waves from SN1897A.

During her PhD studies, Dr Chung acquired invaluable skills and experience to transition smoothly into a new field: technical experience from contributing to LIGO's large software suite and handling 'big data', which helped her to configure complex climate models; and communication skills—essential in any scientific field—as she learned how to give presentations, write papers and professionally respond to the peer review process.

Working with LIGO exposed Dr Chung to an incredibly high standard of scientific vigour. Although a PhD in astrophysics is challenging, it taught her how to approach problems in a methodical way, question *everything,* and report findings accurately—essentially, how to be a scientist.

CAREER CASE STUDY:

DR JIELAI ZHANG

Dr Jielai Zhang is an OzGrav postdoctoral researcher who has applied novel data science and deep learning techniques to the seemingly disparate fields of astronomy and medial imaging.

Dr Jielai Zhang. Photo supplied.

Jielai completed an undergraduate degree in engineering and science, majoring in maths and physics at the University of Sydney before crossing continents to take a PhD in astrophysics and astronomy at the University of Toronto. During her PhD, Jielai learned the value of taking scientific risks and pushing boundaries in her work. She built a new telescope, the Dragonfly Telephoto Array, using a previously unproven novel design. She wanted to explore faint galaxies that nobody had looked at before and had to build a new telescope to see it.

At the end of her PhD, Jielai become interested in a new field of astronomy called 'Time Domain Astronomy', which looks at how the Universe changes on a very fast time scale. This new field of astronomy requires very fast exposure times which acquire a lot of data, so she had been looking into new techniques, methods and tools from other fields that could apply to this huge data volume in astronomy. That's when she came across medical imaging, deep learning and machine learning. She zeroed in on medical imaging and started to investigate it because of the way it applied a method called 'Deep Learning' which she found was useful to astronomy. Jielai was intrigued to learn more and pivoted into another field via the Schmidt Science Fellowship. During her fellowship year hosted at IBME at the University of Oxford, she shifted her focus to work on biomedical imaging at IBME at the University of Oxford.

Now, as an OzGrav researcher at Swinburne University, Jielai is confident knowing that she can approach and get advice from a network of people outside of her field. This is particularly useful when applying deep learning and machine learning to new types of data.

CAREER CASE STUDY:

DR SHAUN HOOPER

After finishing his PhD with the gravitational wave group at the University of Western Australia, Dr Shaun Hooper moved back to Melbourne and commenced a Commercial Analyst role within the Australian retail arm of a large multinational energy company called Simply Energy/ENGIE. Expanding on his research knowledge, Shaun gained experience across the business in other roles, such as acting General Manager, Gross Margin & Settlements Manager and Risk Analyst. Now as a Risk Manager at Meridian Energy Australia/ Powershop, Shaun manages the portfolio compliance with risk management policies and provides strategic analysis and advice to senior management.

Dr Shaun Hooper. Photo supplied.

Most of Shaun's roles have centered around the modelling and optimising of hedging strategies. Retailers face the financial risk of selling a product to a customer at a fixed price whilst taking on an unknown and highly volatile cost to supply. Generators face the opposite risk of having fixed input costs but an uncertain and variable revenue. Hedging is the practice of trading financial instruments (derivatives) between two counterparties that face the opposing risks to mitigate the exposure to uncertain prices. In practice, retailers exchange price risk for volume risk (the risk of buying too much or too little derivatives).

Similar to the research undertaken with OzGrav, Shaun has faced problems in his roles without known solutions. Using his research background, Shaun developed predictive models for retail load consumption via resource gathering (how to acquire data), data management (how to organise data), coding and experimentation (how to use data), and finally communication (how to present and interpret data to stakeholders).
Analytical, statistical and quantitative skills acquired through scientific research has helped Shaun quantify the risks present in the business: this may mean building Monte Carlo simulations, Value-at-Risk measurements, or credit risk assessment.