YOU TO THE POWER OF *us* CAN BRING THE UNIVERSE INTO VIEW

Department of Physics and Astronomy

ABOUT US

The Department of Physics and Astronomy's researchers enjoy an international reputation as leaders in their fields. We run an active and rigorous research program of national and global significance. Our physical sciences research rates at the highest level in the Excellence in Research for Australia evaluations – well above world standard – as does our research in the subdisciplines of astronomical and space sciences, and optical physics.

Our teaching staff are active researchers, recognised at both national and international levels for their pioneering work, and have strong links with the local community and industry stakeholders. Our physicists have partnered in a number of successful commercial ventures that have led to spin-off companies.

Publications and citations are generated at a consistently high level every year, and our researchers are regularly featured in leading international research journals.

PURPOSE

The department is one of Australia's leading physical sciences departments, recognised globally in astronomy, quantum physics, photonics and laser science.

We are committed to honouring, embracing and fostering equity and diversity in all forms – in our workforce and our community.

We offer rich and distinctive research-integrated and employment-ready undergraduate degrees that are a first choice for school leavers in our region and beyond.

Our graduate research programs provide well-developed pathways to research independence for academic and industry careers, with international aspects in all research projects.

We foster and further develop a strong and visible representation in the local and wider communities as an authority in physical sciences, research, outreach and education.

RESEARCH CENTRES

Every staff member is a member of at least one university research centre, and we host two nodes of the Australian Research Council (ARC) Centres of Excellence:

- ARC Centre of Excellence for Engineered Quantum Systems (EQuS)
- ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP)

MACQUARIE UNIVERSITY RESEARCH CENTRE FOR ASTRONOMY, ASTROPHYSICS AND ASTROPHOTONICS

The centre's researchers collaborate worldwide to study the formation and evolution of planets, stars and galaxies through observational astronomy and theoretical astrophysics, and use cutting-edge astrophotonics technology to build astronomical instrumentation for the most advanced telescopes in the world.

MACQUARIE UNIVERSITY PHOTONICS RESEARCH CENTRE

Through research excellence and rewarding collaborations, the centre explores the science of light and photons in photonics sources, lasers and optical materials, and their applications in life and health sciences, the environment, astrophotonics and quantum photonics.

The centre's research ranges from fundamental research to commercial partnerships and spin-off companies. The centre collaborates with local and international partners in sectors as diverse as advanced manufacturing, medical devices and imaging, environmental sensing, structural monitoring and defence.

QUANTUM ENGINEERING

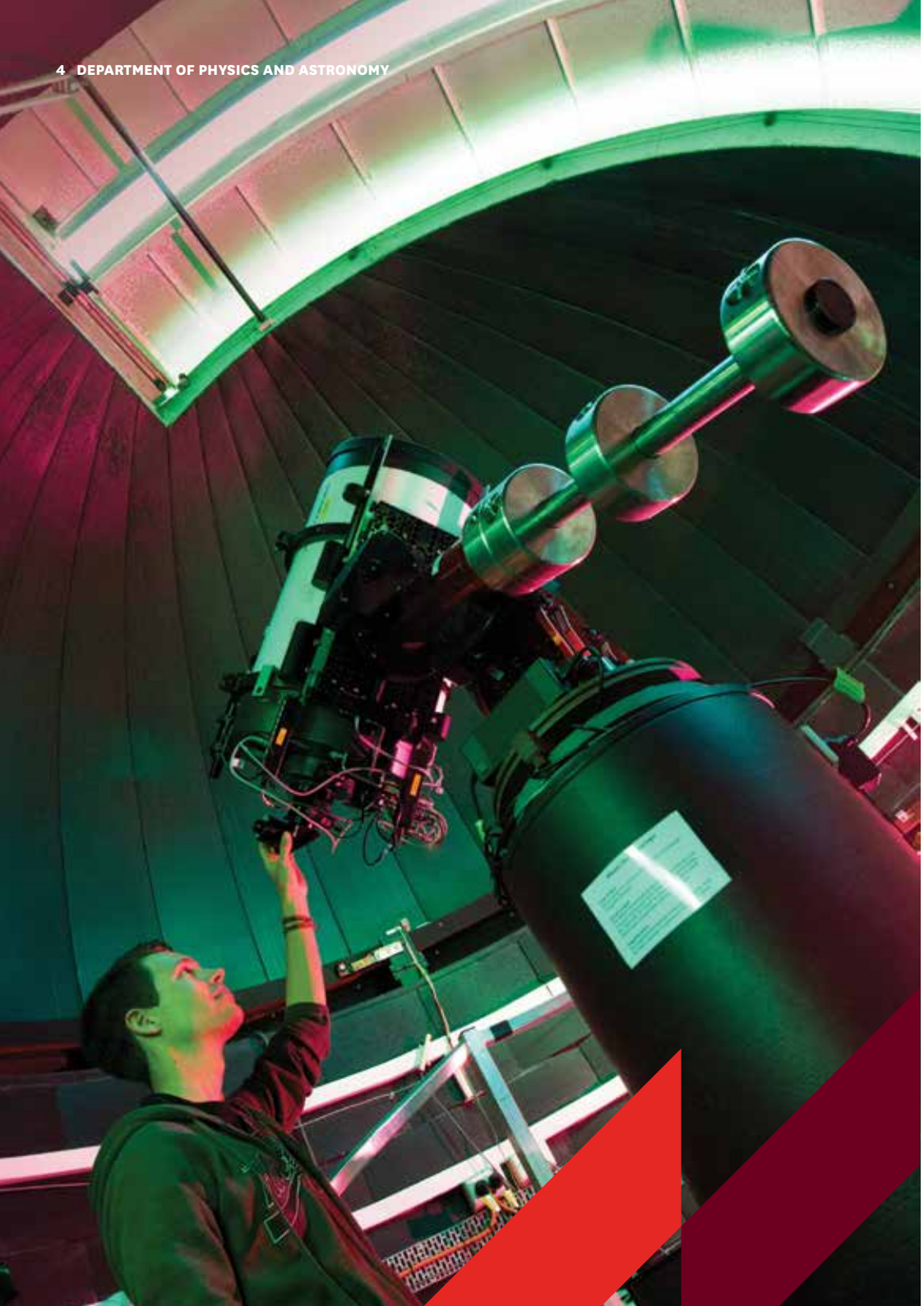
The Macquarie University Research Centre for Quantum Engineering (MQCQE) comprises a team of researchers who are harnessing the laws of quantum mechanics, learned by fundamental research, for practical applications. Activities range from developing quantum algorithms for quantum computers and simulators, to designing and building quantum sensors for ultra-high precision gravitational and electromagnetic field detection, and to interfacing quantum machines into larger networks. The MQCQE is bringing many types of expertise together to tackle these issues in the same manner that engineers approach such problems, all guided by the principles of quantum information and control theory. The MQCQE hosts three quantum laboratories on campus and at CSIRO, and a node of the ARC Centre of Excellence in Engineered Quantum Systems (EQuS).

SYDNEY QUANTUM ACADEMY

The MQCQE is the focal point for Macquarie's membership in the Sydney Quantum Academy (SQA). The SQA is a consortium of four universities dedicated to making Sydney an international hub for training in quantum computing and engineering, with support for PhD scholarships, industry training, postdoctoral fellowships and distinguished visitors. The MQCQE members are delivering postgraduate-level courses for the full cohort of SQA scholars as well as Master of Research students.

DIAMOND SCIENCE AND TECHNOLOGY

The Macquarie University Research Centre for Diamond Science and Technology (DSciT) brings together researchers from a wide range of disciplines – including chemistry, cognitive science, engineering, molecular science and physics – to focus on developing novel solutions to tomorrow's questions using the unique and fascinating properties of diamond.



RECENT DISCOVERIES

DEVELOPMENT OF COMPACT TERAHERTZ SOURCES – LASER SOURCES BASED ON STIMULATED POLARITON SCATTERING

Our goal is to develop practical and efficient sources that deliver the power, tunability and spectral resolution required for real-world terahertz (THz) imaging and spectroscopy applications in diverse areas such as plant physiology, drug identification and biomedicine.

INVENTION OF THE DIAMOND RAMAN LASER

Diamond lasers are a Macquarie-led patented innovation for boosting laser capabilities and performance. The technology is currently directed towards addressing the challenging laser needs for applications in long-range sensing, space environment, defence and advanced manufacturing.

QUANTUM COMPUTING

Developing a useful quantum computer is a major goal of 21st-century quantum physics. But most known algorithms for quantum computers solve quite obscure problems. In partnership with industry, we have developed much faster quantum techniques to simulate the electronic structure of materials, key to designing new drugs or fully engineered compounds. By making this important commercial problem easier for a quantum computer to solve, we are bringing applied quantum computing closer to reality.

THE FASTEST HYPERVELOCITY STAR

A project studying the outskirts of the Milky Way has led to the discovery of the fastest 'normal' star in the Galaxy, one ejected by the supermassive black hole at the galactic centre five million years ago and currently racing towards intergalactic space at more than six million kilometres an hour. It is the first star we can trace unambiguously to the central black hole, yielding clues to star formation in the violent heart of the Galaxy.

FACILITIES

Our award-winning research and innovative teaching programs are underpinned by state-of-the-art facilities. Our researchers have access to outstanding specialist photonics, quantum and optics laboratories, and laser processing and optical characterisation facilities, as well as our on-campus astronomical observatory. We collaborate closely with local, national and international observatories.

Our facilities also include:

- Access to onshore and offshore 2–10 metre telescopes, including the European Southern Observatory's Very Large Telescope
- Laser micromachining, nanocharacterisation and diamond growth facility in the OptoFab node of the Australian National Fabrication Facility (ANFF)
- Major 3D metal printing facility in steel and titanium
- More than 30 well-equipped laboratories and clean rooms
- Optical and photonic micro-characterisation and microscopy facilities
- Thin-film deposition
- Access to national supercomputer facilities
- Quantum levitation and cryogenic facilities

ASTRONOMY

JOANNE DAWSON

SENIOR LECTURER
ARC DECRA FELLOW
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- Galactic interstellar medium
- Radio astronomy of molecular tracers
- Star formation

RICHARD DE GRIJS

PROFESSOR
E: richard.de-grijs@mq.edu.au

- Star clusters
- (Multiple) stellar populations
- Galactic structure, nearby galaxies and magellanic clouds
- Star-formation histories
- Astronomical distance scale
- Variable stars
- History of science

ORSOLA DE MARCO

PROFESSOR
E: orsola.demarco@mq.edu.au

- Stellar astronomy and theory
- Theoretical/computational research on binary stars interacting with one another and their planets

DEVIKA KAMATH

LECTURER, ARC DECRA FELLOW
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- Chemical composition of evolved stars, and origin of the elements in the universe
- Single and binary stellar evolution and nucleosynthesis
- Structure and evolution of the circumstellar environment of evolved stars: second generation protoplantetary disks, jets and more
- Interaction mechanisms in binary star systems

RICHARD MCDERMID

SENIOR LECTURER
ARC FUTURE FELLOW
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- Using the motions and chemistry of stars to understand the origins of galaxies
- Detecting and measuring the properties of supermassive black holes
- Using and developing new instrumentation for the world's largest telescopes

MATT OWERS

SENIOR LECTURER
E: matt.owers@mq.edu.au

- Galaxy clusters, mainly focusing on galaxy evolution and the impact of environment on galaxy star formation
- Spectroscopic surveys

CORMAC PURCELL

LECTURER
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- Magnetism and star formation in the Milky Way Galaxy
- Machine-learning tools for discovery within, and analysis of, large datasets
- Cross-disciplinary research in ecology and archaeology

LEE SPITLER

SENIOR LECTURER
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- Understanding how galaxies form and evolve through cosmic time
- Pursuing creative ways to view the universe using new technology
- CubeSat space-based astronomy

MARK WARDLE

PROFESSOR
E: mark.wardle@mq.edu.au

- Theory of interstellar processes
- Star and planet formation
- Magnetohydrodynamics

DANIEL ZUCKER

ASSOCIATE PROFESSOR
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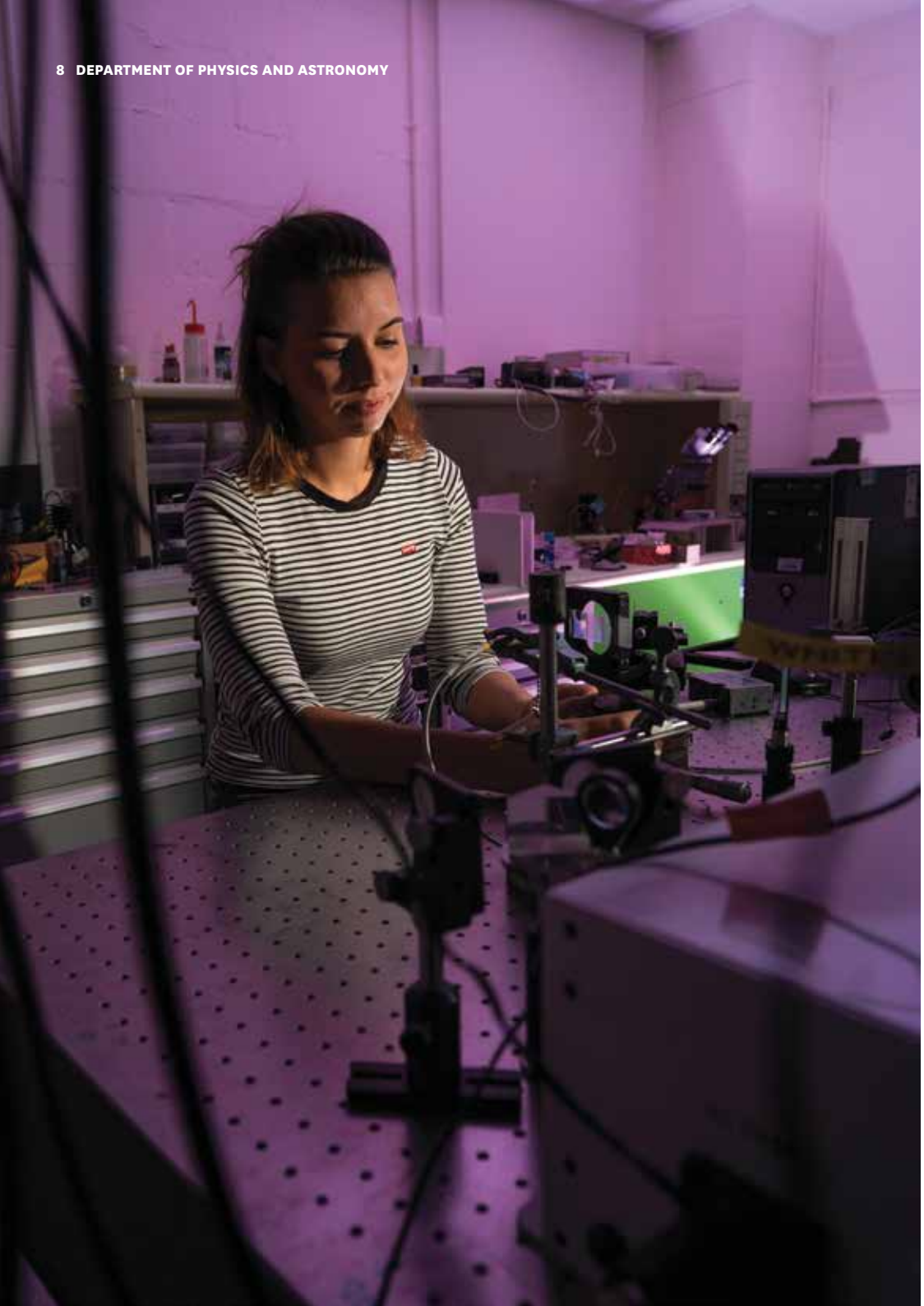
- Observational astronomy, including ground and space-based observations
- Observation of resolved stellar populations
- Optical and infrared spectroscopy and imaging, including stellar streams and stellar structures



PHOTONICS

DAVID COUTTS
PROFESSOR
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- Laser physics
- Astrophotonics
- Novel ultraviolet lasers (particularly cerium lasers)
- Vortex beams and propagation in multimode optical fibres
- Astronomical instrumentation, including spectrographs and their calibration for exoplanet science

JUDITH DAWES
PROFESSOR
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- Nanophotonics
- Random lasers
- Plasmonics
- Laser applications in medicine

JAMES DOWNES
ASSOCIATE PROFESSOR
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- Condensed matter
- Organic semiconductors
- Synchrotron X-ray studies of electronic structure
- Neutron scattering studies of magnetic structure
- Magnetic semiconductor materials for spintronics applications
- Diamond integrated electronics and devices
- Materials and processes for organic electronics fabrication
- Micro magneto-mechanical systems for fundamental/quantum physics studies

ALEX FUERBACH
ASSOCIATE PROFESSOR
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- Development of mid-infrared fibre laser sources
- Fabrication of integrated photonic devices
- Development of integrated chip lasers

DEB KANE
PROFESSOR
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- Photonics dynamical systems, including chaotic output
- Quantifying experimental time-series data, including for quantifying complexity and chaos
- Optics and optical materials of spider webs and spider silks, and related bio-optics
- Nanometrology – pioneering optical interferometric microscopy techniques
- Laser materials processing
- Photonics-based conservation science for Aboriginal and Oceania art and cultural heritage

ANDREW LEE
RESEARCH FELLOW
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- Compact terahertz radiation sources using solid-state lasers, towards practical applications for terahertz radiation
- Raman lasers that operate in the visible wavelength range
- Nonlinear optics

RICH MILDREN
PROFESSOR
E: rich.mildren@mq.edu.au

- Diamond optics
- Advanced laser materials
- Nonlinear optics and photonics
- Light applications

HELEN PASK
PROFESSOR
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- Raman lasers
- Terahertz lasers
- Raman spectroscopy and remote sensing

CHRISTIAN SCHWAB
SENIOR LECTURER
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- Astrophotonics
- Astronomical instrumentation
- High-resolution Doppler spectroscopy
- Exoplanet detection and analysis
- Precision photometry

DAVID SPENCE
PROFESSOR
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- Ultrafast lasers
- Nonlinear optics
- Raman lasers
- Ultraviolet lasers
- Terahertz lasers

MICHAEL STEEL
PROFESSOR
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- Nonlinear integrated and quantum photonics
- Sound-light interactions in nanoscale wavelengths and Brillouin scattering
- Periodic optical structures
- Non-reciprocal and one-way optics

MICHAEL WITHFORD
DISTINGUISHED PROFESSOR
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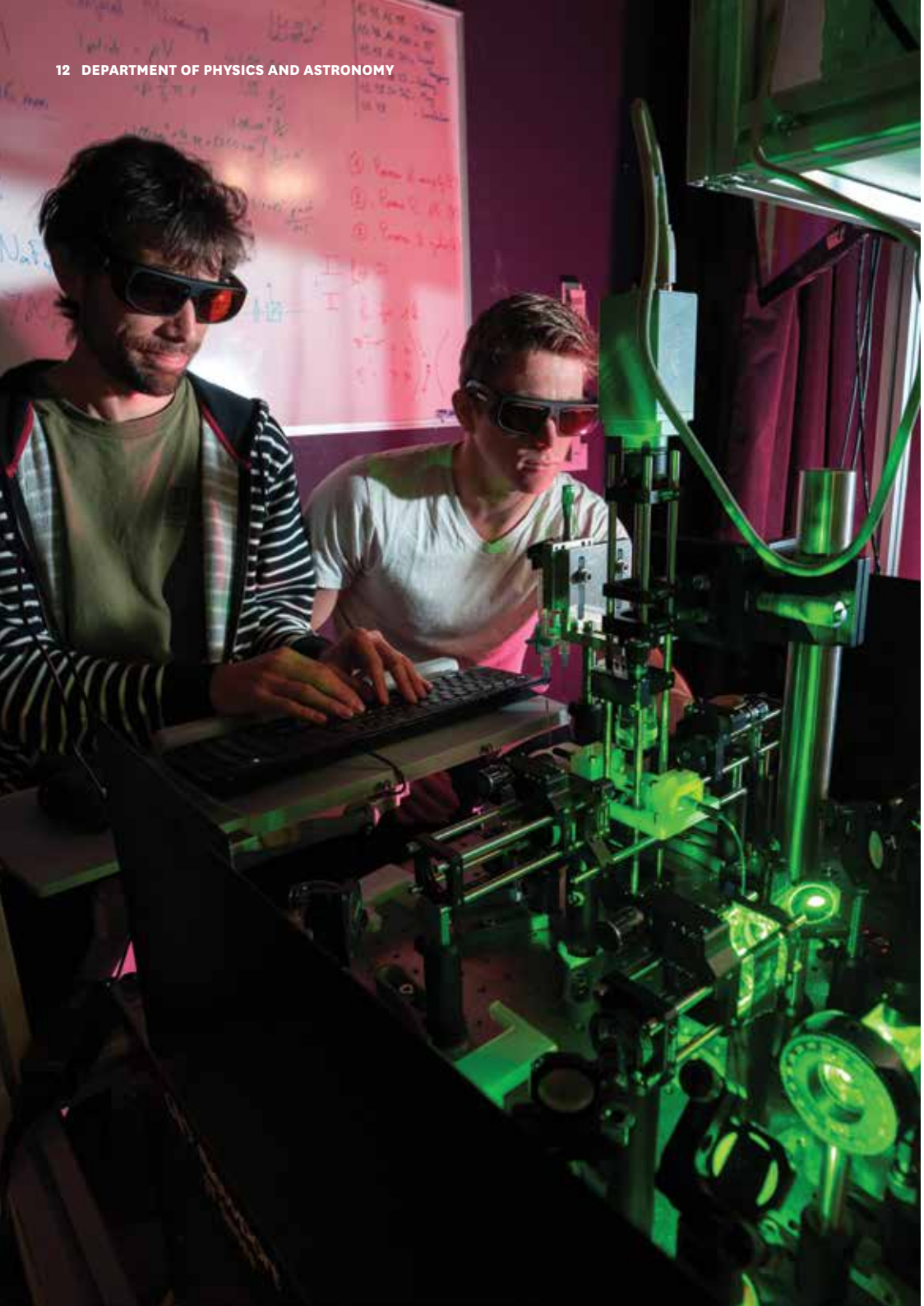
- Astrophotonics
- Telecommunications
- Smart sensors



QUANTUM PHYSICS

DOMINIC BERRY

ASSOCIATE PROFESSOR
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- Quantum algorithms for quantum chemistry research
- Quantum algorithms for solving linear equations research
- Techniques for adaptive phase measurements

GAVIN BRENNEN

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- Quantum computation
- Quantum simulation
- Many-body quantum information atomic/molecular/optical physics

DANIEL BURGARTH

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ARC FUTURE FELLOW
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- Quantum control
- Quantum information
- Mathematical structures

ALEXEI GILCHRIST

ASSOCIATE PROFESSOR
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- Quantum information theory
- Quantum thermodynamics
- Quantum optics

LACHLAN ROGERS

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- Quantum information processing with colour centres in diamond
- Nitrogen-vacancy colour centre in diamond
- Quantum sensing, and cryogenic spectroscopy of diamond
- Nanoscale diamond material

DANIEL TERNO

ASSOCIATE PROFESSOR
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- Quantum information
- Relativistic aspects of quantum information
- Foundations of quantum theory, open systems and complexity
- Quantum gravity and black hole physics
- Precision tests of relativity

JASON TWAMLEY

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E: jason.twamley@mq.edu.au

- Quantum optics
- Hybrid quantum devices
- Quantum magnetometry

THOMAS VOLZ

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- Experimental quantum physics
- Solid-state quantum optics
- Strongly correlated states of matter and light
- Quantum engineered nanomaterials for applications in quantum sensing, simulation and computation

BIOPHOTONICS

YIQING LU
ARC DECRA FELLOW
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- Luminescent nanoparticles and nanophotonics
- Multiplexed biodetection and bioimaging
- Super-resolution microscopy

ANNEMARIE NADORT
NHMRC EARLY CAREER RESEARCH FELLOW
E: annemarie.nadort@mq.edu.au

- Fluorescence-guided surgery of brain tumours
- Tissue engineering of brain tumours (in vitro)
- Non-invasive blood flow imaging using laser speckle flowmetry
- Upconversion nanoparticles for biomedical applications

ANDREI ZVYAGIN
ASSOCIATE PROFESSOR
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- Optical theranostics using optical and photonics solutions for diagnosis, treatment (therapy) and monitoring of the treatment outcome
- Cancer nanotechnology
- Photoluminescent nanomaterials
- Biomedical imaging and sensing

JIM PIPER
EMERITUS PROFESSOR
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- Advanced bioimaging program based on lanthanide nanoparticle probes
- Single-cell detection of pathogenic organisms and cancer cells in complex samples
- Multiplexed biodiagnostics based on life-time coding
- Upconversion nanoparticles for security inks and infrared vision

PHOTO: Tony Crawshaw

MACQUARIE University

At Macquarie, we know that research is the key to unlocking a secure future. It's central to everything we do. And everything we do is for the benefit of humanity and life. Our research is influenced by the big picture: finding solutions to critical global challenges – such as health, safety, climate crisis, and food and water security.

Ranked in the top one per cent of universities around the world*, we are home to leading researchers – a community of accomplished academics that unites collective thinking and expertise across all disciplines and areas of study.

As a researcher, research student or collaborator, you'll work alongside world-leading experts, and have access to world-class facilities and partnerships. We encourage you to find out more about our research priorities and projects.

*QS World University Rankings, 2019

FIND OUT MORE
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