

FACULTY OF  
SCIENCE AND  
ENGINEERING



MACQUARIE  
University  
SYDNEY · AUSTRALIA

(YOU) *us*

**YOU TO THE  
POWER OF *us*  
COULD SEE THE  
FUTURE IN THE STARS**

Australian Astronomical Optics

### ABOUT US

Joining Macquarie University on 1 July 2018, Australian Astronomical Optics (AAO) is a recognised world leader in astronomical instrumentation. AAO-Macquarie has significant expertise in developing innovative technology for use in astronomical instruments, in developing data systems for the storage and access of data from such instruments, and in using these instruments for scientific research.

AAO-Macquarie is the Sydney arm of what used to be the Australian Astronomical Observatory, which opened in 1974. After Australia entered into a 10-year strategic partnership with the European Southern Observatory (ESO) in 2017, the observatory's operating model changed – moving from the government sector to the university research sector.

Macquarie is excited to take a significant role in growing Australia's global position in astronomical instrumentation. We are partnering with the Australian National University, the University of Sydney and Astronomy Australia Ltd to establish a new national capability for astronomical instrumentation under the banner Astralis Instrumentation Consortium (Astralis).

AAO-Macquarie is continually developing the team's decades-long reputation for building world-class optical instrumentation. Our current significant projects include:

- AESOP (a robotic positioning system that rapidly moves 2400 optical fibres simultaneously to micron-level precision, for the European Southern Observatory's VISTA telescope in Chile)
- MAVIS (Multi-conjugate Adaptive optics Imager and Spectrograph for Very Large Telescope, ESO Chile)
- DOT (High resolution Spectrograph for Devasthal Optical Telescope, India)
- Data pipeline software development of the European Southern Observatory (ESO)

For more information about our projects, please go to [mq.edu.au/aao](http://mq.edu.au/aao).

### PURPOSE

Macquarie brings to the AAO a well-demonstrated track record in developing new technologies, with a commercialisation focus, alongside industry partners on campus. AAO-Macquarie's team of experts will build on the University's existing strengths in astronomy, photonics, laser technology, microfabrication, applied optics, sensing and communications.

This collaboration will combine unique capabilities in wide-field and adaptive optics, precision mechanical and optical engineering, design and test, and software to build cutting-edge instruments for the world's leading 8-metre telescope and next-generation 30-metre telescope.

Together, we also seek to increase industry engagement, identify opportunities to apply AAO-Macquarie's expertise to medicine and defence, and expand our presence in the fields of optics and sensing, as well as progress our ongoing mission of world-leading excellence in astronomical instrumentation.

### RESEARCH CENTRES

AAO-Macquarie researchers collaborate with researchers from the School of Mathematics and Physical Sciences.

- Macquarie University Research Centre for Astronomy, Astrophysics and Astrophotonics
- Macquarie University Photonics Research Centre





Milky Way above the Anglo-Australian Telescope  
PHOTO: Angel Lopez-Sanchez

## RESEARCH AREAS

### ASTRONOMY TECHNOLOGY

AAO-Macquarie's key technology strengths include:

- Photonics and other optical-fibre technologies that capture and filter light
- Positioning systems that place optical fibres with maximum efficiency
- Spectrographs that analyse captured light

### ASTRONOMY DATA MANAGEMENT

AAO-Macquarie is also at the forefront of developing an e-research platform and data archive that facilitates cutting-edge science through its Data Central capability. It provides web-based tools and archive functionality for scientists from a range of disciplines to explore, collaborate and make new discoveries.

[datacentral.org.au](http://datacentral.org.au)

### ASTRONOMY RESEARCH

AAO-Macquarie is home to a dynamic and diverse research group. AAO-Macquarie astronomers collaborate with astronomers across the globe and are recognised leaders in many areas of research. Our astronomers and instrument scientists work together to produce some of the world's most innovative and groundbreaking instrument technologies.

### CAPABILITIES

Astronomical instruments are used to collect data in the form of images and spectra from astronomical sources such as stars, galaxies and nebulae. Such instruments typically comprise bulk optics (lenses, mirrors, diffraction gratings, filters), photonic elements (optical fibres and waveguides), optomechanics (to accurately position all of the optical elements), mechatronics (fibre positioning robots and alignment mechanisms), detectors (charge-coupled device and infrared arrays), and software systems (for control and data processing, storage and management).

The techniques and competencies required for these complex and high-precision systems are provided by our staff across the following key areas.

### PROJECT MANAGEMENT

- Project management using waterfall and agile approaches
- Systems engineering (documentation and requirements tracking)
- Risk analysis, mitigation and management
- Quality assurance
- Project financial forecasting and budget tracking

### MECHANICAL ENGINEERING

- Mechanical conceptual design and development
- Mechatronic design
- Optomechanical mounting design
- Cryogenics design and detector development
- Mechanical fabrication (ie standard milling, lathing and computer numerical control (CNC))
- Inventor 3D modelling
- Jigs, fixture and tooling design
- Metrology (eg coordinate measuring machine)
- Vibration and earthquake analysis
- Heat transfer modelling
- Pneumatic systems
- Hydraulic systems
- Finite element analysis
- Failure modes and effect analysis

### ELECTRONICS

- Systems analysis, design and integration
- Schematic and PCB design using Altium CAD software
- PCB assembly and rework with through-hole and surface-mount technology components
- Electronics enclosure and front panel design using mechanical CAD software
- Electronics enclosure wiring and integration
- Electronics enclosure test and debug
- Cable assembly design and wiring
- Programmable logic controller and programmable automation controllers design and programming
- Embedded controller and microprocessor design, including C/C++ firmware development and test
- Motion control and servo systems design, build and test
- Detector controller and detector system design, build and test
- Fibre positioner design incorporating advanced robotics, including piezo actuator systems
- LTSpice circuit simulation
- Radio frequency-related design, including electromagnetic compatibility compliance and antenna design
- Cryostat electronics design support and manufacture.

### OPTICAL DESIGN

- Optical systems design (Zemax)
- FRED scattered light and thermal analysis
- Optical systems assembly, integration and testing
- Micron-level alignment and testing
- Photometric metrology
- Interferometric metrology
- Large volume-phase holographic grating characterisation
- Fibre characterisation
- Fibre and photonic chip polishing

### PHOTONICS

- Photonic beam propagation, finite element simulations and finite difference time domain simulations
- Nanophotonic alignment and testing



Starbug robotic fibre positioners under development for the TAIPAN instrument  
PHOTO: Andy Green

## INSTRUMENT SCIENCE RESEARCH AND DEVELOPMENT

- Robotic fibre positioning technologies
- OH suppression with fibre Bragg gratings
- Silicon photonics for astronomy
- Photonic simulations and modelling
- Fluoride fibres
- Fibre bundles for adaptive optics wavefront sensing
- Focal plane positioning technologies for large payloads
- Low surface brightness imaging arrays from low-cost telephoto lenses

## TELESCOPE INSTRUMENTATION SOFTWARE

- Software algorithm and systems design
- Astronomical instrumentation control software development, testing and integration
- Instrument control and monitoring
- Data reduction, analysis and pipeline software design and development
- Full software lifecycle for instrumentation and data reduction projects
- Main languages used at the moment include C/C++ 11+, Python, Fortran 2003, Java, Perl, Shell, Tcl/Tk running on Linux/Unix, MacOS, and VxWorks platforms

## DATA

- Configuring, administering and managing: Hadoop clusters, PrestoDB, SQL databases (including MySQL, PostgreSQL, MS SQL Server), MongoDB databases
- Developing with Docker images and containers
- Building web applications using various web frameworks (Python/Django, Node.js, PHP)
- Configuring and managing web servers, including Apache httpd and Tomcat
- Managing cluster hardware, including deployment, networking (Ethernet and Infiniband) and maintenance

## ASTRONOMY

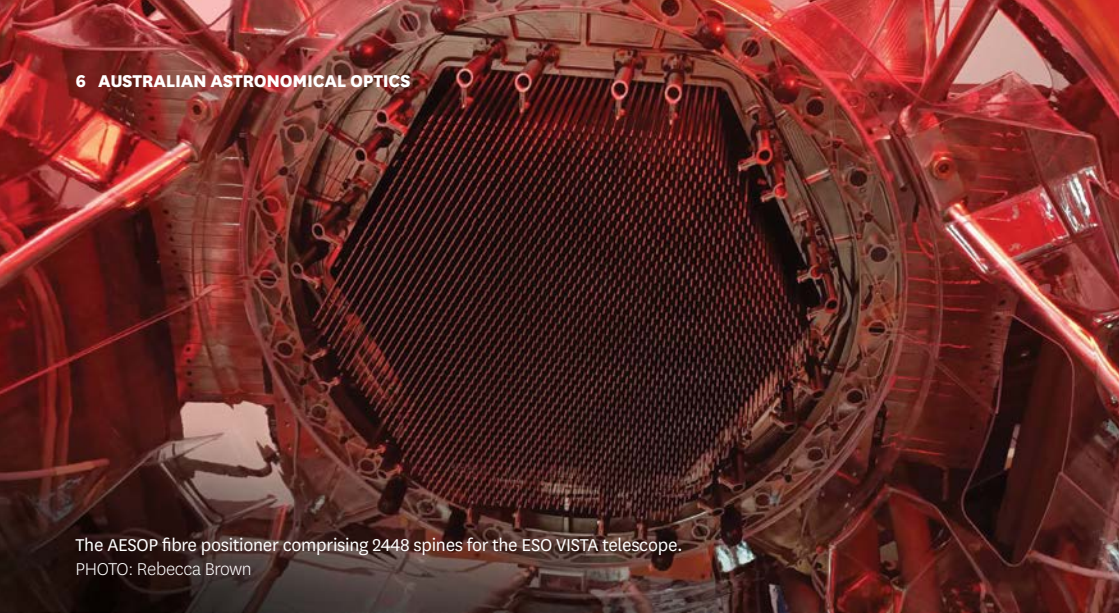
Research areas include:

- Galaxy evolution
- Star formation
- Stellar evolution
- Chemical evolution of stars and galaxies
- Galaxy dynamics

Major international survey programs include:

- GAMA ([gama-survey.org](http://gama-survey.org))
- GALAH ([galah-survey.org](http://galah-survey.org))
- EMU ([emu-survey.org](http://emu-survey.org))
- 4MOST Science Overview ([4most.eu/cms/science/overview](http://4most.eu/cms/science/overview))





The AESOP fibre positioner comprising 2448 spines for the ESO VISTA telescope.  
PHOTO: Rebecca Brown

Meet our dedicated leadership and management team.

### DIRECTOR

#### MARK CASALI

PROFESSOR

E: [mark.casali@mq.edu.au](mailto:mark.casali@mq.edu.au)

- Astronomical visible/infrared detector development
- Instrumentation for astronomical research



### INSTRUMENTATION

#### JON LAWRENCE

PROFESSOR

HEAD OF INSTRUMENTATION

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- Astronomical instrumentation and technology development



#### DAVID ROBERTSON

PROGRAM AND PROJECTS

MANAGEMENT GROUP MANAGER

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- Program management
- Emerging technology deployment
- Software as a platform architecture



#### SIMON ELLIS

INSTRUMENTS AND PROJECT

SCIENCE GROUP MANAGER;

ASSOCIATE PROFESSOR

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- Astronomical instrumentation research and development
- OH suppression with fibre Bragg ratings and ring resonators
- Astrophotonics
- Multi-conjugate adaptive optics-assisted instruments
- Astrophysics of positronium



### ENGINEERING

#### NICK CERNEAZ

HEAD OF ENGINEERING

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- Organisational development
- Technical & service governance
- Product & project quality



#### LEWIS WALLER

ELECTRONICS GROUP MANAGER

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- Anglo-Australian Telescope detector system support
- Instrument control systems for 4MOST/AESOP and GHOST





AAO-Macquarie optical engineers measuring the throughput of each optical fibre.  
 PHOTO: Morris McLennan

**JESSICA ZHENG**

OPTICS GROUP MANAGER

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- Adaptive optics and wavefront sensor technology
- Optical system scattering light and thermal analysis
- Optical metrology



**HELEN MCGREGOR**

MECHANICAL GROUP MANAGER

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- Instrumentation design, development and implementation
- Fibre positioner systems
- Optomechanical design



**RESEARCH, DATA AND SOFTWARE**

**NURIA LORENTE**

SOFTWARE GROUP MANAGER

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- Astronomical instrumentation software
- Robotic fibre positioning systems
- Data reduction algorithms and software
- Astronomical data simulation
- Software engineering development within the astronomical community



**SIMON O'TOOLE**

DATA/IT GROUP MANAGER

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- Database technologies and data management
- Web technologies
- Research systems administration



**ASTRONOMY AND PROJECT SCIENCE**

**ANDREW HOPKINS**

PROFESSOR

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- Evolution of galaxies over cosmic history
- Processes and evolution of star formation within galaxies
- Interplay between star formation and supermassive black holes in galaxies
- Instrumentation project scientist



**OPERATIONS**

**LISA PESAVENTO**

OPERATIONS MANAGER

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- Budget management
- Strong customer service focused
- Process improvement – development and testing
- Relationship building at all levels





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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COVER PHOTO: The AESOP fibre positioner comprising 2,448 spines for the ESO VISTA telescope, Rebecca Brown  
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