

MONASH  
PHYSICS AND  
ASTRONOMY

[study.monash](http://study.monash)

# PHYSICS AND ASTRONOMY

**Have you ever wondered if absolute zero temperature can be reached, how a black hole forms, or what the Universe is made of? Have you ever had a CT, an ultrasound or an MRI scan? Do you use a smart phone, the internet or a computer?**

Almost everything that makes your life more comfortable, or allows you to work efficiently in the 21st century, is due to engineered solutions based on physical principles. The discovery of electricity, magnetism, relativity and quantum mechanics came about through human curiosity, but did not have practical applications until much later.

Physicists and Astrophysicists explore the Universe at all scales of length, time and energy – from sub-atomic particles (such as the recently discovered Higgs boson) to the large scale structure of the Universe; from ultra cold gases (close to absolute zero temperature), to what happened at the Big Bang. Physics seeks to understand the nature of space, time and matter, and in doing so it addresses profound philosophical questions about the nature of reality and the origin of our Universe.

The skills you gain through studying physics and astrophysics at Monash can be used in many areas, such as: developing medical instrumentation, radiotherapy treatment of cancer, modelling climate and weather, analysing big data and financial systems, developing innovative ways to address sustainability, exploring emergent behaviour in complex biological systems, and understanding the function of the brain.

Physics and astronomy at Monash is going through an exciting period of growth – investing significantly in people and facilities. We are working across a broad range of creative, curiosity-driven research areas that will impact on future generations – including, biomedical imaging, quantum computing, atomtronics, and novel materials for next generation photonics, optoelectronics and spintronics.

## FACILITIES

Students have access to research facilities in the New Horizons Research Centre, the Monash Centre for Astrophysics, The Monash Centre for Atomically Thin Materials, the Monash Centre for Electron Microscopy and the Australian Synchrotron. The School hosts the ARC Centre of Excellence in Future Low Energy Electronics Technologies (FLEET), and is a major node of two other ARC Centres of Excellence in Particle Physics and Gravitational Wave Astrophysics. This combination of world class facilities provides unique opportunities for students studying physics or astrophysics at Monash.





## PHYSICS AND ASTRONOMY COLLABORATIVE-LEARNING ENVIRONMENT (PACE)

We've developed a new way of teaching physics and astronomy, which we call PACE. The PACE model of Studio Physics and Astronomy replaces lectures with hands-on learning in small groups.

Studio Physics and Astronomy teaches students creative problem-solving, effective communication, teamwork and adaptability in spaces purpose-built for this way of learning. We are creating a community of students who are active learners and are able to apply the knowledge they have learned, within and outside of the classroom – in creative and imaginative ways.

## NEW HORIZONS RESEARCH CENTRE

The New Horizons Research Centre opened in 2013. It is a \$175M research and training complex that houses the research laboratories of the School of Physics and Astronomy. The New Horizons Research Centre brings together world-class researchers from Monash and CSIRO, with diverse backgrounds in physics, astrophysics, engineering, IT and biosciences. The scope of the new Horizons Research Centre is beyond anything else that exists in Australia – drawing on an incredible array of talent, state of the art equipment and specialised infrastructure to generate and develop innovative ideas across disciplines. It houses the Monash Centre for Atomically Thin Materials and the ARC-funded Centre of Excellence in Future Low Energy Electronics Technologies (FLEET), where researchers are pushing the boundaries of the new quantum revolution.



# WHAT TO EXPECT IN FIRST-YEAR PHYSICS AND ASTRONOMY

Monash is one of a small number of universities in Australia that offers the full spectrum of subjects in physics, astronomy and astrophysics. Studying at Monash allows you to explore everything from atomic physics to ultracold gases; from computational astrophysics to observational astronomy; from condensed matter physics to nanotechnology; from electron microscopy to synchrotron science; from elementary particle physics to quantum cosmology; from biophotonics to optoelectronics; from medical imaging to x-ray science, and much more. If you have a passion for physics and/or astronomy, then Monash is the place for you!

The subjects on offer in the minors, majors and extended majors are complemented by facilities that are the best in the world. The Monash experience includes hands-on activities in our laboratories and the use of optical/radio telescopes at our astronomical observatory. You will have access to state of the art equipment, computing facilities, and custom-designed spaces that promote learning and student-staff interactions. You will have the chance to carry out a genuine research project and publish your work in peer-reviewed journals. You will benefit from working with researchers who are world leaders in their fields. At Monash you have the opportunity to build skills that are highly valued by employers, and achieve your potential.

## SEMESTER ONE

Name	Unit information	What you will study
Classical physics and relativity <b>PHS1011</b>	If you have sufficient high school physics and/or mathematics (for specifics, see the handbook entry for this unit) and wish to study physics or astrophysics, you need to take this unit. This unit builds on the topics you have already studied. Calculus is required.  MTH1020 (or equivalent) is recommended alongside PHS1011 because this is the level of maths required for the subsequent unit, PHS1022, in semester 2.	Classical mechanics, oscillations & waves, and special relativity.
Foundation physics <b>PHS1001</b>	This unit is for students who wish to study physics or astrophysics but do not meet the requirements for entry to PHS1011.  No specific prerequisites; a general science and mathematics background is sufficient. No calculus is used – though, if you study physics beyond this unit you will need calculus. For further progression in physics, MTH1020 (or equivalent) is recommended alongside PHS1001.	Mechanics, waves, electricity & magnetism, and basic quantum physics.
Physics for the living world <b>PHS1031</b>	Suitable for students with a broad interest in science – of particular relevance to students interested in biology, physiology and biomedicine.  No specific prerequisites; a general science and mathematics background is sufficient. No calculus is used.	Important biophysical processes involving: energy, biomechanics, fluids, sound, light and electricity.  Key technologies, such as radiation therapy and medical imaging systems, will also be studied.
Earth to cosmos – introductory astronomy <b>ASP1010</b>	This unit is suitable for students with a broad interest in science, or to complement your other studies in physics or astrophysics. There are no specific prerequisites; a general science and mathematics background is sufficient.  Note: If you plan to continue with astrophysics at second level, you will need to take PHS1022 or PHS1002 and the relevant maths units.	Provides an introduction to astronomy, including planets, the solar system, stars, galaxies, cosmology and extreme events in the Universe.

## SEMESTER TWO

Name	Unit information	What you will study
Fields and quantum physics <b>PHS1022</b>	This unit continues on from PHS1011; it requires PHS1011 and MTH1020, or equivalent. It provides a route to physics at higher levels.  MTH1030, or equivalent, is recommended alongside PHS1020 as this is the level of maths required for second year (Level 2) physics and astrophysics units.	Rotational dynamics, gravity, electromagnetism and quantum physics.
Physics for engineering <b>PHS1002</b>	This unit continues on from PHS1001, or can provide an entry point to physics for students entering in semester 2; it requires PHS1001, or equivalent, and an understanding of calculus. It provides a route to physics at higher levels.  For further progression in physics, MTH1030 (or equivalent) is recommended alongside PHS1002.  This unit can also be taken as an elective unit by Engineering students who have passed PHS1001 or high school physics.	Rotational dynamics, gravity, electromagnetism and quantum physics.
Life in the universe – astrobiology <b>ASP1022</b>	This unit is suitable for students with a broad interest in science, or to complement your other studies in physics or astrophysics. There are no specific prerequisites (e.g., you do NOT require ASP1010 to select ASP1022); a general science and mathematics background is sufficient. No calculus is used.  Note: If you plan to continue with astrophysics at second level, you will need to take PHS1022 or PHS1002 and the relevant maths units.	The characteristics of life, how life first appeared on Earth and the conditions for life to appear elsewhere in the cosmos.

# WHERE PHYSICS OR ASTROPHYSICS CAN TAKE YOU

## Our graduates have varied and diverse career options

Studying physics or astrophysics at Monash can take you to places we are yet to imagine. Graduates with physics or astrophysics majors are highly skilled in empirical reasoning, computational and theoretical modelling, data analysis and visualisation. At Monash we will help develop and hone these skills and, of equal importance, we will provide you with an environment in which you can work as part of a team, communicate your ideas, think creatively and solve problems. These are essential skills for the workplace, and key to any career.

### Some career options include:

- Accelerator physicist
- Acoustician
- Astrophysicist
- Atmospheric physicist
- Big data analyst
- Biophysicist
- Climate modeller
- Electron microscopist
- Energy consultant
- Environmental physicist
- Financial analyst
- Forensic physicist
- Geophysicist
- Industrial physicist
- Information security analyst
- Instrumentation physicist
- Materials scientist
- Metallurgist
- Medical physicist
- Nuclear physicist
- Optical physicist
- Observational astronomer
- Particle physicist
- Patent attorney
- Physics teacher
- Radiation oncology physicist
- Radiation protection practitioner
- Renewable energy manager
- Solar energy physicist
- Synchrotron scientist
- Science journalist
- Telecommunications consultant
- University lecturer



### CHRIS WHITTLE

Studying Science at Monash gave Chris flexibility in choosing his subjects, allowing him to build his degree around his passions. Collaboration with physics researchers has been a highlight of his studies, and Chris is a member of the LIGO Scientific Collaboration, which announced the detection of gravitational waves in 2016, one hundred years after their prediction by Einstein. During his honours year, Chris spent three months in the United States working on the commissioning of Advanced LIGO to improve the sensitivity of the interferometer to gravitational waves. Chris is currently undertaking a PhD at the Massachusetts Institute of Technology.



### LINDA CROTON

Linda studied astronomy in the United States and Germany, and worked as a spacecraft controller for two NASA science missions at the University of California, Berkeley's Space Sciences Laboratory. After several years away from science, to start a family and move to Australia, she decided to pursue a PhD. Monash offered the best opportunity for Linda to combine her experience in image analysis with an interest in medical imaging. She is developing new techniques for imaging the brain to enable the visualisation of soft tissue structures at a higher resolution than was previously possible.

# OUR RESEARCH

## The School conducts research within four broad research areas

In the most recent national audit of research excellence (ERA 2015), the School obtained the maximum overall rating of 5 for Physical Sciences, including the maximum rating of 5 in each of our assessed fields of research – one of only a handful of universities in Australia to achieve this outstanding result.

### THE QUEST FOR NEW PHYSICS AND SYMMETRIES

Researchers in the School are tackling some of the most profound questions in science, such as the origin of space, time and matter. We study the ultimate building blocks of nature – the basic objects that make up our Universe and the physical laws that govern them. Our research encompasses both standard model physics, such as electroweak interactions and quantum chromodynamics (which describes quarks and gluons), and physics beyond the standard model, including: dark matter, dark energy, supersymmetry, the origin of neutrino masses, matter-antimatter asymmetry, extra dimensions and quantum cosmology. As a major partner in the ARC Centre of Excellence for Particle Physics at the Terascale, we conduct research in collaboration with leading groups worldwide, including CERN – home of the Large Hadron Collider.

### THE NEW QUANTUM REVOLUTION

The first quantum revolution uncovered the rules which govern the behaviour of atoms – quantum mechanics. Understanding and applying these rules are pivotal to technologies that underpin much of modern society. For example, the computer and communications revolution is based on our ability to control electrons and photons.

In the 21st century, we are poised to take advantage of a new quantum revolution – one which will allow us not only to understand the behaviour of atoms, but to engineer and control quantum states of matter and light with unprecedented precision, as in the emerging area of atomtronics.

The School has established the Centre for Atomically Thin Materials, focussed on transformative technologies for society, such as graphene-based electronics, spintronics, photovoltaics and nano-engineered quantum devices.

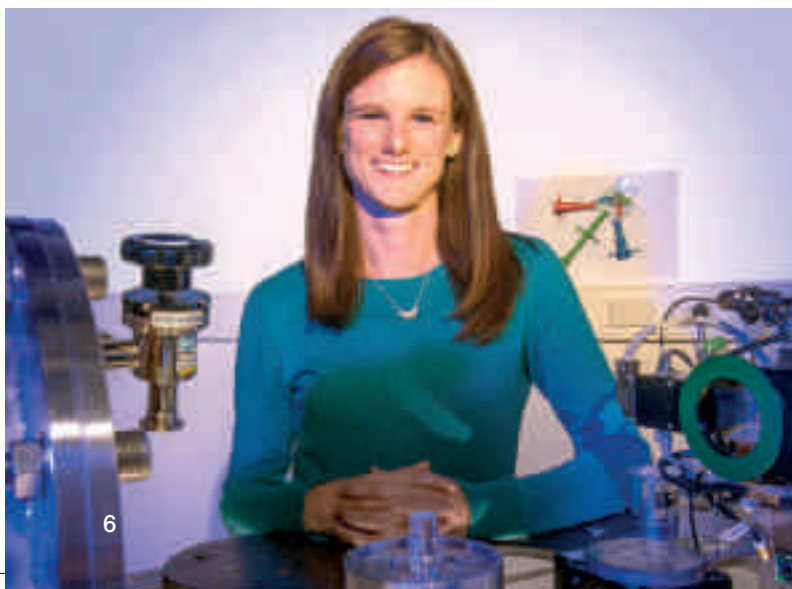
In 2016 the School was awarded funding for a major new ARC Centre of Excellence in Future Low Energy Electronics Technologies (FLEET), which has set itself the ambitious goal of re-inventing the building blocks of the next generation of electronics, based on revolutionary new ideas in topological states of quantum matter.

### A WINDOW ON THE UNIVERSE

Astronomers and astrophysicists in the School are exploring the Universe – from the Big Bang and first stars to the largest cosmological scales. The School hosts the Monash Centre for Astrophysics (MoCA), which is one of the most diverse astrophysics research groups in Australia. Major areas of research include: active galaxies, astrophysical fluid dynamics and magnetohydrodynamics, galaxy evolution, first stars, the formation of stars, stellar evolution, stellar nucleosynthesis, nuclear astrophysics, chemical evolution, galactic archaeology, supernovae, supernova remnants, neutron stars, stellar transients, supermassive black holes, high energy astrophysics, gravitational wave astronomy, stellar and planetary dynamics, and exoplanets. Our researchers utilise major observational and supercomputer facilities and we are involved in planning for the next generation of observatories, such as the SKA and Giant Magellan Telescope. The School is also a member of the Joint Institute for Nuclear Astrophysics and has close collaborations with the Center for Nuclear Astrophysics at Shanghai Jiao Tong University. In 2016 the School became a major partner in the ARC Centre of Excellence in Gravitational Wave Discovery (OzGrav), allowing us to capitalise on the new age of gravitational wave astronomy.

### NEW WAYS OF SEEING AND UNDERSTANDING THE WORLD

Imaging and computational sciences have driven discoveries in materials science, biological sciences and medicine. The School is a leader in imaging with light, x-rays and electrons. Using world-class imaging facilities in the Monash Centre for Electron Microscopy (MCEM), the New Horizons Research Centre, the Australian Synchrotron (adjacent to Monash), and synchrotron radiation facilities in Europe, Japan and the United States, we are carrying out research that is positively impacting on the future prosperity and health of our nation. Our insights with x-ray phase contrast imaging of lung aeration at birth have provided better care for infants born preterm with under-developed lungs, thereby increasing survival rates. Other research, focused on imaging the airways during delivery of a treatment for Cystic Fibrosis, has improved our understanding of this genetic disorder. Researchers using the world's most advanced electron microscopes in MCEM are developing new ways of imaging and designing advanced functional materials. From atom to device and from molecule to organism, physics has a critical role to play in 21st century technology and biology – it is central to the development of tools and insights that will enable new discoveries and for the understanding of complex systems.



#### DR KAYE MORGAN

Kaye is a VESKI Fellow and former ARC DECRA Fellow, who works in the field of phase contrast x-ray imaging (PCXI) using synchrotron radiation. The techniques developed by Kaye have been applied to sensitively image soft tissue at high resolution. Her work on imaging the airways has led to improved treatment of Cystic Fibrosis. As part of her current VESKI Fellowship, Kaye is spending two years at the Institute for Advanced Study at the Technical University of Munich, where she is developing new generation x-ray sources capable of capturing not only structural information, but also high-speed dynamics in an “x-ray movie”.

# SOME OF OUR PEOPLE



## ASSOCIATE PROFESSOR MEERA PARISH

Meera is a leading young theoretical physicist working in ultracold atomic gases and superconductivity. Since obtaining her PhD in 2005, Meera has made significant contributions to our understanding of new states of quantum matter and the collective behaviour of fermionic condensates, superconductivity, and magnetotransport. Her outstanding contributions to these fields led to the award of the Institute of Physics Maxwell Medal and Prize in 2012 (previous winners include Stephen Hawking and Nobel Laureates).



## DR JASMINA LAZENDIC-GALLOWAY

After obtaining her PhD in Australia, Jasmina held postdoctoral fellowships at the Harvard-Smithsonian Center for Astrophysics and MIT. She then came to Monash as an inaugural Margaret Clayton Fellow in 2008. Her research involves supernova remnants and neutron stars, both products of massive star explosions. Jasmina is also passionate about learner-centred practices and incorporating the excitement of scientific research into her undergraduate courses. She is using innovative teaching practices in the School's new first year Physics and Astronomy Collaborative-learning Environment (PACE), where she teaches introductory astronomy and astrophysics, using a Studio approach to student learning.



## ASSOCIATE PROFESSOR DANIEL PRICE

Daniel is an ARC Future Fellow who kicked off his career with a science degree at Monash. This led to a PhD at the University of Cambridge and two postdoctoral fellowships before he returned to Monash. Daniel develops advanced simulation techniques for astrophysics (using some of the world's most powerful supercomputers) to model the birth of stars from interstellar gas clouds, the formation of planets from discs around newborn stars and the flow of gas around black holes. Techniques and computer codes developed at Monash are used around the world for modelling all kinds of exotic astrophysical phenomena.



## DR KAVAN MODI

Kavan is an ARC Future Fellow who works in quantum information sciences. Instead of trying to understand the details of specific systems involving atoms or photons, he tries to make sense of the logic of the quantum world. He investigates how the rules of quantum mechanics could allow us to solve tough problems, make better sensors, and transport energy faster. Kavan has made substantial contributions to our understanding of noisy quantum correlations in quantum technologies, such as quantum computers and sensors. Presently, he is developing a theoretical framework to characterise the most general aspects of quantum dynamics, with applications to quantum batteries and the emerging area of quantum biology.



## ASSOCIATE PROFESSOR PETER SKANDS

Peter is an ARC Future Fellow whose research interests are closely tied to the Large Hadron Collider (LHC) at CERN in Geneva, where he used to work. The LHC is a high energy particle accelerator and the world's largest scientific instrument. Its extreme energies give rise to spectacular phenomena called 'jets' (sprays of nuclear matter produced by fragmenting quarks and gluons) and 'strings' (which enforce confinement of quarks and gluons inside 'hadrons'). Peter is the author of an advanced set of computational tools called PYTHIA, which are used to accurately model high energy particle collisions. PYTHIA was exploited in the discovery of the Higgs boson and is one of the most highly cited particle physics publications in the world.



## PROFESSOR MICHAEL FUHRER

Professor Michael Fuhrer is an ARC Laureate Fellow and Director of the Monash-led ARC Centre of Excellence in Future Low Energy Electronics Technologies (FLEET), which aims to re-invent the transistor based on new developments in condensed matter physics, such as topological insulators. Michael has also set up the Monash Centre for Atomically Thin Materials, to explore the forefront of two-dimensional (2D) materials, such as graphene – a single atomic layer of graphite found in ordinary "lead" pencils. His research team is investigating many novel 2D layered materials, with applications in spintronics, nanoscale electronics, optoelectronics, and photovoltaics. These new materials have the potential to revolutionise electronics and computing by developing an alternative to silicon-based chips.



## Further information

[monash.edu/physics](http://monash.edu/physics)

1800 MONASH (1800 666 274)

The information in this brochure was correct at the time of publication (June 2017).  
Monash University reserves the right to alter this information should the need arise.  
You should always check with the relevant Faculty office when considering a course.

Designed and produced by SMC Monash. 17P-0629.  
CRICOS provider: Monash University 00008C