We are a global hub of disruptive Photonics and Advanced Sensing research, creating transformational new approaches to sensing, and a new profession of transdisciplinary problem solvers.
IPAS is one of five world-leading research institutes at the University of Adelaide. The mission of IPAS is to use the power of light to make the world a healthier, wealthier, safer and smarter place. We are doing this by building unique sensors which harness the powerful properties of light to learn about the environment: this might be inside the human body where we are building tools to diagnosis disease, inside an aircraft where we can search for hidden corrosion, inside a nuclear reactor where we want to measure radiation, or mapping methane leaks for environmental monitoring.

This broadness of applicability is captured in our Science Themes: three Themes cover fundamental research on new types of glass, optical fibres and laser sources, while three apply our devices to make critical measurements in the biological, medical, defence, environment, astrophysical and resources areas. Most IPAS researchers and projects sit across multiple themes demonstrating our vision of nurturing transdisciplinary skills for a new generation of insightful and effective research leaders.

IPAS focuses on three key points in addition to the research excellence of its members:

a) Transdisciplinary vision which brings together physicists, engineers, biologists, material scientists and chemists.  
b) Focus on engagement with industry. IPAS has specific funding schemes such as the Photonics Catalyst Program to enhance interaction with industry.  
c) Focus on timely execution and commercialisation of research breakthroughs. IPAS has already spun-out two companies with several more in the pipeline.

We have just passed the milestone of five years since our launch and it seems sensible to reflect on all that has been achieved. In early 2013 we moved into the new $100M Bragg building and we are constantly amazed at the brilliant working environment we have – the architecture of the building reflects the intent of the personnel – open, transparent and collaborative minds built with the power of glass and light.

Within this building we have installed an advanced manufacturing capability: 3D metal and ceramic printing, ultrasonic precision machining of glass, crystals and metal, laser development and optical fibre manufacture, as well as a unique accredited laboratory dedicated to mixing physics and biology. We thank the SA Government, DSTO, DefenceSA, the University of Adelaide and the Federal Government for providing the funding and support that enabled us to create these world class facilities. These capabilities are open to all and we welcome any interest you might have so that together we can produce new and innovative products.

The culmination of this effort and expertise was rewarded with a successful bid for a new $38M ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP) which was led by IPAS founding Director Professor Tanya Monro. This Centre will greatly enhance leading-edge research at the nexus between biology, physics and chemistry. The CNBP will bring an influx of new researchers into IPAS at the University of Adelaide, as well as into our partners at RMIT and Macquarie University.

Building a vibrant research eco-system with a focus on translation and engagement is crucial for the prosperity of South Australia and the nation. IPAS provides the facilities and focus to support researchers to do this in the fields of sensing and photonics. I hope that you will engage with the Institute so that together we can realise these goals.

Professor Andre Luiten  
IPAS Director
The breadth of research conducted by IPAS members is categorised under six Research Themes, each led by a pair of Theme Leaders who are knowledgeable of the science and research programs within the Theme. The role of the Theme Leaders is to advocate for the needs arising from the Theme, to develop strategies to grow opportunities for the Theme, and to facilitate action within the Theme. The Theme Leaders are responsible for facilitating opportunities between IPAS Themes, endorsing applications for internal IPAS Schemes, and organising annual Theme events.
Theme Goals

The six Research Themes have helped us to better communicate the work we do with our partners and stakeholders, and have served to crystallise transdisciplinary projects that sit outside traditional discipline boundaries.
The IPAS Student Experience

Study at IPAS

IPAS Honours, Masters and PhD opportunities are state-of-the-art and guided by dedicated research scientists who are world leaders in their field. As well as working on blue sky research, we also work in partnership with government and industry on projects aimed at delivering real-world outcomes. Our graduates have gone on to postdoctoral roles at leading research organisations worldwide, others have secured employment with industry partners, defence, or pursued careers in banking, patenting or management consultancy (including Schlumberger, DSTO, BAE Systems, Maptak, Coherent, Lastek and the Australian Antarctic Division).

Please see our list of currently available positions at: adelaide.edu.au/ipas/postgraduate-research

IPAS Science Network

The Science Network team has been created to strengthen the bond between science disciplines of the University and bring together members and non-members of IPAS for fun networking events and professional development activities. The IPAS Science Network represents the needs of the students within IPAS and supports students in all aspects of their postgraduate experience. The IPAS Science Network team are Jonathan Hall (Chair), Matthew Briggs (Vice-Chair), Myles Clark (Treasurer), Kelly Keeling (Secretary), Georgina Sylvia (Media), Elizaveta Klantsataya, Chao Zhang and Parul Mittal.

Science photography competition sponsored by IPAS

Roof top BBQ
The IPAS Student Experience

Ms Eleanor King – PhD Student

Before starting my PhD I completed my honours year with the School of Mechanical Engineering, studying crack formation in pipeline steels.

In my PhD project I study how the mirrors in the LIGO (Laser Interferometer Gravitational-wave Observatory) interferometers heat up due to absorbed laser light. Currently I am working with supervisors Dr David Ottaway and A/Prof Peter Veitch along with Dr Yuri Levin from Monash University to develop a new and faster method for calculating thermal deformations in an object due to any thermal profile.

This work will be used for noise reduction in gravitational wave interferometers, which are ultimately expected to make the first direct detection of gravitational waves, as predicted by Einstein’s theory of relativity.

Mr Malcolm Purdey – PhD Student

My PhD project, under the supervision of Prof Andrew Abell and Prof Tanya Monro, has involved collaboration with Cook Medical to produce functional sensors of hydrogen peroxide produced by embryos under stress.

Working in IPAS has removed many difficulties associated with interdisciplinary work, as I have been able to synthesise new compounds in one lab, and characterise them in an optics lab next door.

The broad applicability of the fluorescent sensors for hydrogen peroxide in this project has generated significant interest leading to an opportunity to collaborate with Prof Aitken at the University of Newcastle studying the generation of hydrogen peroxide by defective sperm.

This work will lead to new fluorescent compounds attached inside microstructured optical fibres, for non-invasive monitoring of hydrogen peroxide levels near embryos, giving a strong indication of the embryo’s health.

Ms Juliane Schuppich – Visiting Masters Student

I am a Master student at the German University of Technology Ilmenau. To expand my research experience and to look for new horizons I decided to spend six months in Australia working at IPAS. This was an amazing opportunity for me.

A/Prof Heike Ebendorff-Heidepriem was my supervisor and we worked together on the development of an indium fluoride step-index fibre. We were able to create some new glass compositions and found some surprising new properties of the indium fluoride glass. I was given the opportunity to do things myself and was very proud of my first successful glass production.

Australia is an exciting country with an amazing range of landscapes. I visited rainforests, deserts and mountain ranges, and enjoyed observing the wildlife, including kangaroos, emus and lizards. I visited Brisbane, Sydney and Melbourne, each with its own character and many things to discover. However, I fell in love with Adelaide.
RESEARCH THEME:
Novel Light Sources

IPAS novel light sources research combines fundamental and applied physics to generate and deliver tailored light for medicine, national security, industrial and environmental monitoring, and fundamental physics applications.

Our world leading research includes:
- Fibre and planar waveguide lasers
- Frequency combs
- Ultra-narrow linewidth lasers
- Fibre-based nonlinear devices
- Solid-state lasers
- Fibre based super-continuum sources.

Real world applications for these sources include:
- High-speed and high-resolution molecular spectroscopy for trace-gas detection
- Precision measurement
- Spectroscopic sensors
- Defence Precision Technologies
- Laser-based electronic warfare systems
- Atmospheric and coherent laser radars.

Fibre and Planar Waveguide Lasers

Our Fibre and Planar Waveguide Lasers research is focussed on developing and optimising new concepts in fibre and planar waveguide lasers. Our research is driven by the challenge to develop lasers that operate in fringe regimes and possess extreme capabilities from compact architectures. This work drives the development of unique rare-earth doped glasses and fibres at IPAS.

Precision Measurement

A defining feature of our technological society is a hunger for more accurate and precise measurement and sensing. The Precision Measurements Group (PMG) aims to build instruments that can meet this need. We are interested in measurements that are of high value and interest to fundamental physics as well as in industrial, biological and defence contexts.

Although this approach may seem rather esoteric it turns out that many key devices of modern society are based on high-quality clocks, lasers and oscillators. As examples, one can look at the Global Positioning System (GPS) satellite system, magnetic resonance imaging, radar, optical fibre communications and even mobile phones. The PMG is pushing the development of clock and oscillator technology to provide a revolutionary capability in these important fields.

Nonlinear Optics

Our expertise in modelling nonlinear processes in nanoscale waveguides could provide future solutions for high-speed optical switches, laser sources and sensing architectures. The ongoing development of fundamental theory has led to new models that predict a novel ‘self-flipping of polarization states’ that are being explored via two new collaborations. We hold high hopes for some very interesting new light sources in the near future.

Solid State Lasers

Solid State Laser research at IPAS focuses on the development of low noise and high-power systems for specific applications including ultra high precision measurement, spectroscopy, and remote sensing. This year we have demonstrated a laser that produced the shortest pulses ever achieved by an Er:YAG laser pumped by inexpensive laser diodes. This is approaching the pulse durations needed for this laser to replace more complicated non-linear optics based solutions for long distance laser range finders.
**PHOTON INTERACTIONS**

A device that allows photons to interact with each other has been developed. Photon-photon interactions are difficult to engineer, but are crucial for optical quantum computing.

Collaboration with University of Western Australia, University of Queensland and Universite de Limoges, France.

Perrella, C, Light, PS, Anstie, JD, Benabid, F, Stace, TM, White, AG, Luiten, AN (2013), High-efficiency cross-phase modulation in a gas-filled waveguide, Physical Review A - Atomic, Molecular, and Optical Physics, 88, 013819. Funded by ARC DP0877938, DE120102028, FT0991631, and the ARC Centres of Excellence EQuS and CQC2T. Supported by the South Australian Government through the PSRF.

**NONLINEAR 3-PHOTON GENERATION**

We investigated the use of nanoscale optical fibers to fuse three photons into one photon or split a photon into three photons. Using this we can develop new fibre-base laser sources with the capability to produce entangled triplet photons for quantum applications.

Collaboration with the University of Auckland, NZ and the University of Southampton, UK.


**MID-IR CHIP LASER**

The longest wavelength waveguide laser at 2.9 µm has been fabricated. The laser is fabricated by ultra-fast laser inscription in a fluoride glass. The laser has potential for use in biological, medical and remote sensing.

Collaboration with Macquarie University and the University of Sydney.


Shahraam Afshar V (pictured), Max Lohe, Tanya Monro
IPAS chemical and radiation sensing research uses in-house and specialty optical fibres, extensive knowledge of optical spectroscopy and unique surface coatings to develop novel optical fibre-based chemical sensing architectures.

We explore the limits of detection, including:
- Ultra-small volume samples
- Low concentrations
- Obtaining results in difficult to access areas.

Working with end-users and industry, we develop these sensors for monitoring water quality, corrosion, wine maturation, embryos, soil nutrients, fuel degradation and explosives. We are also researching new forms of fibre-based radiation dosimeters for the medical, mining and defence industries.

Chemical Sensing

Our chemical sensing research includes:
- Dip-sensors for hard to access regions including hazardous environments and in vivo.
- Distributed sensors to enable information across a platform or structure.
- Liquid and gas sensing approaches: fluorescence, Raman, plasmonic resonances and other spectroscopic techniques.
- Analytes successfully sensed include hydrogen peroxide (H₂O₂), aluminium ions (Al⁢⁺³), free SO₂, nitroaromatic explosives and metal ions.

In partnership with other IPAS researchers, we have developed new functional structure surfaces to enable advanced sensor functionality. We solve problems in collaboration with irrigation companies, defence organisations, embryologists and oenologists.

Radiation Sensing

Radiation Sensing in IPAS focuses on the development of new radiation dosimetry tools for both fundamental research and real-world applications in health, defence and industry. Examples include:
- Fibre-based distributed dosimeters

Environmental Luminescence

The IPAS Environmental Luminescence laboratory, now named “The Prescott Environmental Luminescence Laboratories”, hosts one of the most comprehensive suites of luminescence research equipment in the world. The suite includes the world’s most sensitive TL (thermoluminescence) spectrometer, a photon-counting imaging system (PCIS) developed in collaboration with ANU, state-of-the-art TL/OSL (optically-stimulated luminescence) Risø readers, fluorescence analysis facilities, and specialised apparatus for the measurement of luminescence kinetics and signal stability.

Environmental Dosimetry and Optical Dating

We develop new forensic luminescence techniques for detection of prior exposure to ionising radiation, and conduct a wide range of collaborative luminescence dating with industry and academia. Luminescence dosimetry techniques are highly versatile: they are able to accurately measure ages from the present day back 500,000 years and quantify doses as low as a fraction of one day’s background radiation. Our research is advancing these techniques and further extending the applicability of luminescence analysis.
Novel luminescence dating techniques & anatomical analyses of seventeen hominin skull specimens to confirm the "accretion model" of Neanderthal evolution at Sima de los Huesos, Atapuerca, Spain.

Collaboration with CENIEH, Complutense University of Madrid, University of the Basque Country BGC, MNHN, Binghamton University, MNHN University of Zaragoza.

Lee J Arnold (pictured), Martina Demuro, Sabrina Heng (pictured), Roman Kostecki, Tanya Monro, Andrew Abell, Nigel Spooner (pictured), Heike Ebendorf-Heidepriem, David Ottaway

Most sensors are single use. We have developed the first nanoliter-scale ion-sensor that can be regenerated on-demand using light. Reusable sensors allow for multiple measurements to be made on a single sample.

Collaboration with DSTO.

The Research Hub will develop, test and commercialise new safe and cost-effective methods to purify uranium and copper concentrates to ensure Australia is a world leader in copper production and associated technology.

Collaboration with Monash University, University of Queensland, University College London, DSTO, Environment Protection Authority, SA Museum, and BHP Billiton.
RESEARCH THEME: Optical Materials and Structures

Capabilities
IPAS delivers vertically integrated expertise and facilities, from modelling to device fabrication.

Modelling
- A suite of analytical, numerical and finite-element modelling tools to predict the optical properties of waveguides and fibres with complex structures
- New theoretical frameworks to explore waveguides and fibres with extreme properties and nanoscale features
- A pulse propagation model to predict how a pulse propagates along a fibre
- Waveguide and fibre design based on reverse engineering techniques
- A suite of numerical and finite-element modelling tools to find resonance modes of microsphere and microdisk cavities.

Fabrication of glasses and fibres
- Controlled atmosphere glass batching, melting and annealing
- Soft and hard glass preform extrusion
- Soft and hard glass preform ultrasonic milling
- Soft glass and silica fibre drawing.

Characterisation
- High-resolution electron and atomic force/scanning near-field optical microscopes (AFM/SNOM)
- Transmission spectrometers and ellipsometers spanning from the ultraviolet to the far-infrared spectral region (200 nm-30 µm)
- Optical profiler to measure surface roughness
- Simultaneous thermal analysis (STA/TGA/DSC)
- Fibre loss measurement.

Research
Our research ranges from fundamental science to application-driven design and development, including:
- Development of glasses with enhanced infrared transmission and optical nonlinearity
- Nanophotonic glasses created by embedding nanocrystals in glass
- Advanced technologies for processing and shaping glass
- Design and fabrication of micro and nanostructured soft glass and silica optical fibres
- Development of specialty doped, active and passive silica fibres, including single-mode germano-silica, rare-earth doped silica and double/triple clad fibres
- Advanced light propagation theory within optical fibres and planar waveguides.

Key areas of strength include:
- Tellurite and fluoride glasses (both passive and active)
- Advanced preform technologies (extrusion and drilling based)
- Development of glasses and fibres capable of transmitting light in the mid-infrared that underpin new sensing platforms and lasers
- Custom silica fibres for fibre lasers, including air-clad rare-earth doped fibres
- Suspended and exposed core silica fibres for sensing.
New glass formulations extends our ability to deliver mid-infrared light through fibre. By investigating the causes of fibre scattering loss in fluoride optical fibres, we have been able to modify the fabrication conditions which can improve the mechanical strength of the fibres.

Collaboration with DSTO.

This work shows that light confinement and slow light contribute to nonlinear behaviour of optical waveguides. This can be employed to design optical signal processing devices.

Collaboration with the University of Sydney.

The ability to harness electrical function in an optical device opens up opportunities. We have demonstrated the feasibility of combining the advantages of soft glass, optical fibres and microstructured fibre design to create electro-optical devices.

Bei, J, Monro, TM, Hemming, A, Ebendorff-Heidepriem, H (2013), Reduction of scattering loss in fluoroindate glass fibres. Optical Materials Express, 3 (9), 1285-1301. Funded by DSTO, ARC FF0883189, an International Postgraduate Research Scholarship (IPRS) and a Discipline of Physics Supplementary Scholarship, the University of Adelaide. Conducted in the AMMRF and ANFF OptoFab facilities.

Afshar V, S, Monro, TM, De Sterke, CM (2013), Understanding the contribution of mode area and slow light to the effective Kerr nonlinearity of waveguides. Optics Express, 21 (15), 18558-18571. Funded by ARC DP110104247.

IPAS research in Molecular Materials and Surfaces spans the following areas:

- Chemical surface coatings
- Surface functionalisation strategies
- Organic synthesis
- Molecular-based sensors
- Bioelectronics
- New materials for gas storage or separation for renewable energy applications
- Platforms for catalysis.

Our researchers include ARC Future and DECRA Fellows, with expertise ranging from fundamental chemistry to analyte-specific sensor development (an IPAS strength).

Key infrastructure is available in the School of Chemistry and Physics, including:

- Synthetic laboratories (wet and dry)
- High field NMR spectroscopy and X-ray diffraction structure determination
- Mass spectrometry
- Automated peptide synthesis
- Analytical and semi-preparative HPLC
- Time-resolved laser spectroscopy
- Materials characterisation capabilities.

Biological and Chemical Surface Functionalisation

Biological and Chemical Surface Functionalisation work at IPAS combines organic synthesis, supramolecular chemistry and surface science to functionalise the surface of a glass optical fibre and other surfaces, enabling the detection of specific chemicals and biomolecules.

New Bioactive Compounds

We design, synthesise and test inhibitors to solve clinical challenges. Our investigations concentrate on proteolytic enzymes and biotin protein ligase as associated with the development of new antibiotics. We work to incorporate molecular ‘switches’ that when activated, mimic a key protein or peptide. Our aim is the improved treatment and diagnosis of Alzheimer’s, traumatic brain injury, cancer and cancer.

Novel Materials Synthesis

Novel Materials Synthesis group design and synthesise nanostructured materials. Some of these compounds display novel interactions and behaviour that we exploit to develop sensors as well as for use in separation science and as platforms for catalysis.

Charge Transfer and Bioelectronics

Our Charge Transfer and Bioelectronics work focuses on the design and synthesis of peptides with specific secondary structures whose electronic properties we then theoretically and electrochemically evaluate on surfaces.

Functional Organic Materials

IPAS researchers working on groundbreaking research in the area of Functional Organic Materials are developing the chemistry of ‘networked polymers’. These materials are synthesised from high symmetry building blocks linked via strong, irreversible covalent bonds. This emerging field has tremendous potential for new and more efficient catalysis platforms, sensing, storage and separation solutions.

Time-Resolved Laser Spectroscopy

Energy and charge transport in organic materials researchers at IPAS use time-resolved spectroscopic techniques to investigate energy and charge transport processes of organic photovoltaic materials. These materials, which include semiconducting polymers and organic crystals, exhibit not only the photovoltaic effect but also the ability to sense the presence of a number of airborne chemical species. Our current work focuses on controlling the photo-physical and chemical pathways to maximise generation of charged species in these materials.
Surface functionalisation allows glass fibres to recognise specific molecules. This is a fundamental step in the fabrication of optical fibre sensors. We used various surface analysis techniques to provide a comprehensive picture of these functionalised glass surfaces and facilitate fibre sensor development.

A new highly selective gas adsorbent material has been developed. The material exhibits exceptional selectivity for CO$_2$ over N$_2$, and has potential application for purifying complex gas mixtures from power plant flue streams into their separate gaseous components in a cost-effective manner. Collaboration with CSIRO.

Electrochemical studies have provided definitive evidence of a direct link between backbone rigidity and electron transfer in peptides. These findings have enabled a novel approach for the development of switchable molecular components. Collaboration with Flinders University.


Herbert Foo (pictured), Heike Ebendorff-Heidepriem, Chris Sumby, Tanya Monro
Witold Bloch (pictured), Christian Doonan, Chris Sumby
Jingxian Yu (pictured), John Horsley, Andrew Abell

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Witold Bloch (pictured), Christian Doonan, Chris Sumby
Jingxian Yu (pictured), John Horsley, Andrew Abell
RESEARCH THEME:
Biological Sensing and Medical Diagnostics

IPAS research in this Theme seeks to:
• Create measurement tools to enable new questions to be asked in biology and medicine (this activity is driven through the ARC Centre of Excellence for Nanoscale BioPhotonics, see page 20)
• Develop improved medical diagnostic techniques, including 'point of decision' technologies
• Advance next generation proteomics technologies for cancer diagnostics and treatment
• Discover and detect biomarkers using Tissue Imaging Mass Spectrometry
• Investigate proteins and peptides underpinning the development and prevention of diseases

Biomarker Discovery
This work investigates cancers through the identification of new biomarkers, increasing our capacity to detect, identify and quantify proteins and peptides with high sensitivity and accuracy. We use mass spectrometry and 2D gel electrophoresis combined with difference gel electrophoresis fluorescence labelling and isotopic labelling for protein identification and quantification. Driven by the need for the early diagnosis of cancer and monitoring of the disease’s progression, it also provides a better understanding of the disease at a molecular level.

Tissue Imaging Mass Spectrometry
In recent years, we have implemented and improved matrix-assisted laser desorption/ionization (MALDI) imaging mass spectrometry (IMS) in our laboratories. MALDI-IMS determines the spatial distribution of unknown compounds in tissue sections. Tissue sections prepared using the standard clinical pathology procedure, formalin fixed-paraffin embedding (FFPE), can be used. During the last decade this technique has been developed as a powerful tool for the discovery of new markers which correlate with disease severity or metastasis as well as for the confirmation of known markers like HER2 receptor status.

Protein Structure, Function and Interactions
Research efforts are directed towards development of new approaches (primarily using mass spectrometry and complementary biophysical methods such as nuclear magnetic resonance spectroscopy, circular dichroism, fluorescence spectroscopy, electron microscopy) to obtain insight into the 3D structure, function and interactions of macromolecules, such as proteins and DNA, important in biology.

Biosensing Platform Development
Harnessing breakthroughs from our other Themes, we create new biosensing tools for advancing biological research, and collaborate with medical researchers to enable translation to clinical applications.

New sensor architectures include:
• Small-volume in-fibre fluorescence assays
• Fibre-tip sensors for in vivo diagnostics
• A multi-channel sensor for virus, bacteria and biomarker detection for gastric cancer.

Central Nervous System Nanoscale Biosensing
Our brains and spinal cords are comprised of billions of highly diverse and specialised cells working in concert, allowing us to process a multitude of conscious and unconscious pieces of information. However, we still only understand a fraction of the complexity of brain function in health, let alone how the brain changes in disease. To tackle the new frontiers in brain and behavioural research we need to ask our scientific questions of smaller and smaller numbers of cells, in very discrete brain regions. Unfortunately, the existing technologies don't allow this. Therefore, through the use of novel nanoscale biosensors our research aims to go beyond the limits of detection imposed by current tools. With these new tools we will ask questions of the brain and spinal cord that was once thought to be science fiction.
The coupling effects between a suspended core optical fibre and a dye-doped spherical microresonator positioned at the fibre’s tip were investigated. We have shown a strong enhancement of the emission from the resonator, resulting in superior sensing capabilities that could be used in vivo.

Currently it is impossible to predict the response to chemotherapy in ovarian cancer. We have developed a method for measuring molecular profiles directly from cancer biopsies. This method will allow personalisation of patient treatment, thereby improving patient outcomes. In collaboration with the Royal Adelaide Hospital.

A new sensor developed by coating the interior of silica capillaries with a sub-wavelength layer of high refractive index, dye-doped polymer has been demonstrated. These sensors could be integrated with existing biological and chemical separation platforms such as capillary electrophoresis and gas chromatography, to develop portable, point-of-care diagnostic equipment.
The team has a wealth of experience in developing the technologies that underpin remote sensing. Our members contribute to international projects such as the Laser Interferometer Gravitational Wave Observatory (LIGO), the High Energy Stereoscopic System (HESS) and the Pierre Auger Observatory.

Gravitational Wave Detection with LIGO

Einstein predicted the existence of gravitational waves, and our researchers are part of the LIGO team that is building a $300M instrument to detect them. We have developed a range of laser systems and optical sensors for advanced gravitational wave detection.

Light Detection and Ranging (LIDAR)

We are developing differential absorption LIDAR (DIAL) to remotely sense chemicals in the atmosphere including CH4, water vapour sensing and SDIs. We are developing coherent laser radar (CLR) systems for a range of eye-safe LIDAR applications including:

- Monitoring dust and pollution emanating from mining and industrial sites
- Mapping wind speeds for wind farm site assessment
- Turbine prediction and turbulence detection for aerospace applications.

Our unique solid-state laser platforms in the near infrared (eye-safe band) and fibre lasers in the mid-infrared underpin these exciting technologies.

High-Energy Astrophysics

High-energy cosmic messengers such as gamma and cosmic rays enable us to study the processes in extreme objects like supernova explosions, pulsars and black holes. Detecting gamma and cosmic rays requires advanced techniques to filter the atmospheric background and apply atmospheric transmission. Our researchers are currently working on projects including the design of gamma ray telescopes and ultra high-energy cosmic ray detectors.

Gamma-Ray Astronomy

The High Energy Stereoscopic System (HESS) is an array of five gamma-ray telescopes in Namibia and is being used to reveal the nature of cosmic-ray and electron accelerators in our galaxy and beyond. The Adelaide team focuses on gamma-ray sources in our Milky Way galaxy and how these objects can influence its evolution. The team also leads Australia’s efforts in developing the next generation gamma-ray facility known as the Cherenkov Telescope Array (CTA) which will be 10 times more sensitive than HESS using an array of up to 100 telescopes.

Cosmic-Ray Astronomy

The Pierre Auger Observatory (PAO) in Argentina is the world’s largest cosmic-ray detector. Cosmic-rays are the charged particles continually raining down on Earth from outer space and their origin remains a mystery. PAO is being used to measure the energies, directions and elemental composition of the highest energy cosmic-rays. The Adelaide team leads efforts in reconstructing these cosmic-ray parameters and the calibration of this data by accurately measuring the atmosphere’s properties at the PAO site.

Space and Atmospheric Physics

The atmosphere and near space environment are critical to life on earth. We use a network of radars, lidars and passive optical instruments to study the structure and dynamics of the atmosphere to validate numerical weather and climate models provided by CSIRO and BOM. We use an extensive instrument cluster located at Buckland Park Field Site to map the winds, temperature and density of the atmosphere from the ground to 90 km. We also contribute to the instrument cluster at Davis Station in Antarctica. We are continually developing new instruments and analysis techniques including the development of a powerful Li Rayleigh Lidar for measuring densities and temperatures in the 30 to 90 km region in collaboration with the Australian Antarctic Division and the Leibniz Institute for Atmospheric Physics in Germany, and a novel UHF radar for measuring winds and turbulence in the lowest 500 m of the atmosphere in collaboration with a local company, ATRAD Pty Ltd.
Einstein’s Theory predicts that periodic gravitational waves are emitted from spinning nonaxisymmetric neutron stars. Our word describes the most stringent upper limit on an all-sky period search for gravitational waves. Once detected they will give new insight into the properties of these amazing astrophysical objects. Collaboration with the LIGO Scientific Collaboration and the Virgo Collaboration.

We have mapped the dense molecular gas in the vicinity of an exploded star. The findings are consistent with a time of approximately 10,000 years passing since the star exploded. Collaboration with the University of New South Wales, Curtin University and Nagoya University, Japan.

Atmospheric gravity waves transfer energy and momentum between the lower and upper atmosphere. We investigated the wave generation created by a powerful thunderstorm and traced the waves through the atmosphere to where they break at heights near 90 km. Collaboration with NorthWest Research Associates Inc., Boulder, Colorado, USA.

We have mapped the dense molecular gas in the vicinity of an exploded star. The findings are consistent with a time of approximately 10,000 years passing since the star exploded. Collaboration with the University of New South Wales, Curtin University and Nagoya University, Japan.

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We have mapped the dense molecular gas in the vicinity of an exploded star. The findings are consistent with a time of approximately 10,000 years passing since the star exploded. Collaboration with the University of New South Wales, Curtin University and Nagoya University, Japan.

Atmospheric gravity waves transfer energy and momentum between the lower and upper atmosphere. We investigated the wave generation created by a powerful thunderstorm and traced the waves through the atmosphere to where they break at heights near 90 km. Collaboration with NorthWest Research Associates Inc., Boulder, Colorado, USA.

We have mapped the dense molecular gas in the vicinity of an exploded star. The findings are consistent with a time of approximately 10,000 years passing since the star exploded. Collaboration with the University of New South Wales, Curtin University and Nagoya University, Japan.

Atmospheric gravity waves transfer energy and momentum between the lower and upper atmosphere. We investigated the wave generation created by a powerful thunderstorm and traced the waves through the atmosphere to where they break at heights near 90 km. Collaboration with NorthWest Research Associates Inc., Boulder, Colorado, USA.
Research Facilities

A number of world-class research facilities underpin the vital research conducted at IPAS, including:

- Optofab – Facilities in Adelaide
- The Adelaide Proteomics Centre
- The STARR Lab (Reproductive BioPhotonics)
- Atmospheric Physics – Buckland Park
- Advanced LIGO
- Bragg X-ray Crystallography Facility
- Environmental Luminescence

These facilities service the needs of IPAS researchers and offer contract services to researchers and companies across the world. The optical fibre fabrication facilities at IPAS form part of the Australian National Fabrication Facility (ANFF), which links eight facility nodes to provide researchers and industry with access to state-of-the-art fabrication facilities.

ARC Centre of Excellence for Nanoscale BioPhotonics

The ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP), which started operations in August 2014, brings together physicists, chemists and biologists, from the University of Adelaide, Macquarie University and RMIT University with key international, national and industry partners, focused on a grand challenge – controlling nanoscale interactions between light and matter to probe the complex and dynamic nanoenvironments within living organisms. The convergence of nanoscience and photonics offers the opportunity of using light to interrogate nanoscale domains, providing unprecedentedly localised measurements. This will allow biological scientists to understand how single cells react to and communicate with their surroundings. This science will underpin a new generation of devices capable of probing the response of cells within individuals to environmental conditions or treatment, creating innovative and powerful new sensing platforms. The $38M Centre has been funded for 7 years by the ARC, State Governments, Universities and Commercial Partners.

For more information please see: CNBP.org.au

Successful CNBP interview panel (Prof Jim Piper, Prof Nicki Packer, Prof Tanya Monro, A/Prof Andrew Greentree, Prof Andrew Abell and Prof Mike Brooks)

Single grain luminescence dating sample preparation under safe light conditions
The Braggs – IPAS Headquarters

The Braggs contains a unique suite of transdisciplinary laboratories including: glass development and processing, optical fibre fabrication, laser and device development, luminescence dating, photonic sensor development, and synthetic, surface and biochemistry. It also includes office space to co-locate IPAS researchers and students from a broad range of scientific disciplines. It also incorporates a 420-seat lecture theatre and other teaching and research facilities.

The Braggs is an accelerator facility, designed to speed up the pace of research by bringing together all the people working in these disparate disciplines and providing them with facilities required to progress further than would be possible in a traditional physics or chemistry lab (for example we now have the ability to bring clinical samples into the laboratories to test them using new measurement tools developed within our labs). All of The Braggs Labs, from the Luminescent Laboratories in the basement, to the Atmospheric Sensing Laboratories on the top floor with access to the sky, are fully equipped to ensure that the researchers are able to undertake outstanding science.

The Braggs

Frequency comb in Precision Measurement Lab

Surface profiler in the Characterisation Suite

The Braggs
IPAS Committees

IPAS Board

Joe Flynn  Mike Brooks  Cathy Foley  Andrew Holmes  Warren Harch  Neil Bryans  Peter Gray  Andrew Dunbar  Amanda Heyworth

IPAS Scientific Management Committee

Andre Luiten  Heike Ebendorff-Heidepriem  Peter Hoffmann  David Lancaster  Andrew Abell  Nigel Spooner  James Anstie

Mark Hutchinson  Georgios Tsimplis  Shahram Atinahpour  Tak Kee  Gavin Rowell  David Ottaway
IPAS Professional Team

Piers Lincoln
Institute Manager

Dale Godfrey
Grants Developer

Luis Lima-Marques
Laboratory Manager

Sara Leggatt
Executive Assistant / Senior Office Administrator

Olivia Towers
(P/T) Administration and Marketing Officer

Silvana Santucci
(P/T) Administration Officer

Jason Dancer
(P/T) Financial Accountant

Valerie Morris
(P/T) Commercial Development Manager

Sara Leggatt

Olivia Towers

Silvana Santucci

Jason Dancer

Valerie Morris

IPAS Science Network

Jonathan Hall
Chair

Matthew Briggs
Vice-Chair

Myles Clark
Treasurer

Kelly Keeling
Secretary

Georgina Sylvia
Media

Elizaveta Klantsiaya
Committee Member

Chao Zhang
Committee Member

Parul Mittal
Committee Member
Industry Collaboration

IPAS engages with industry via consultancy, contract research, collaborative research and Federal Government grants such as industry-linkage schemes.

Commercial contracts with IPAS are handled by Adelaide Research and Innovation (ARI), who manage The University of Adelaide’s commercial research and consultancy partnerships, form new business ventures based on University expertise and develop the University’s innovative ideas and technologies with commercial potential.

IPAS welcomes interactions from potential collaborators in all scientific fields. IPAS already collaborates with many commercial and development organisations including:

Commercialisation

One of the key aims of IPAS is to combine research excellence with a strong industry focus and collaborative culture. The team at IPAS work closely with Adelaide Research and Innovation (ARI), the commercialisation company of the University of Adelaide, to create a culture of innovation within the Institute, foster industry-led collaborations and contract research, and to develop technology licence agreements.

The commercial objectives of IPAS are to accelerate the process of getting products to market, helping the growth of photonics and advanced sensing sectors in Australia, creating new opportunities and jobs for graduates and researchers outside traditional academic roles and securing an untied income stream to the Institute. Through their research, IPAS members have built a significant portfolio of patents.

IPAS Patented Technologies

- Microstructured fibres and nanowires
- A sensor and a method for characterising a dielectric material (VESPR)
- Gastric cancer biomarkers
- Q-switched laser
- A new class of antibiotic
- Waveguide chip laser
- Whispering gallery mode sensor
- Device and method for sensing a chromatic property of foodstuff (browning sensor)
- Optical fibre radiation sensor
- Dual wavelength pumped laser system
- Autoantibody biomarker candidates for early ovarian cancer
- An optical sensor

Contact: Mr Piers Lincoln
T: +61 (0)8 8313 5772
M: +61 (0)410 221 278
E: piers.lincoln@adelaide.edu.au
Photonic Catalyst Program

Building Photonics based collaborations between Industry and the University of Adelaide.

The Photonic Catalyst Program (PCP) is a joint initiative between the Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) and IPAS, and is connecting South Australian Industry with emerging laser and sensor technologies capable of transforming their businesses. It is creating a South Australian based ecosystem of expertise and capabilities in photonics supporting the development of cutting-edge photonic products through unique project based collaborations between researchers, industry, end-users and government.

The Program facilitates the development of advanced photonic devices by coordinating the efforts of key stakeholders. It provides funding mechanisms for engagement, the development of prototypes, testing of photonic devices and the adoption of new light based technologies. We have a particular focus on finding solutions, creating new products and advanced manufacturing opportunities for South Australia.

The $750,000 Program will fund 15 new industry-focused projects between IPAS researchers and local companies over the next 2 years. Participants in the PCP will receive a commercial and technical feasibility assessment of their project and up to $45,000 worth of research and development services to assist with the development of their new photonics product or prototype.

Examples of projects funded so far under this program are:

• S J Chesser – the engineering and testing of high temperature optical fibre sensors at the Port Pirie zinc smelter.
• Maptek – enhancing the performance of Maptek’s I-Site Laser Scanner through the use of additive manufacturing.
• ATRAD – develop a sensor flown on weather balloons from airports to detect freezing conditions in the atmosphere and alert pilots to icing hazards.

Contact: Mr Piers Lincoln
T: +61 (0)8 8313 5772
M: +61 (0)410 221 278
E: piers.lincoln@adelaide.edu.au
Optofab Adelaide Node

The Australian National Fabrication Facility

Established under the National Collaborative Research Infrastructure Strategy, the Australian National Fabrication Facility (ANFF) links eight university-based nodes to provide researchers and industry with access to state-of-the-art fabrication facilities. The capability provided by ANFF enables users to process hard materials (metals, composites and ceramics) and soft materials (polymers and polymer-biological moieties) and transform these into structures that have applications in sensors, medical devices, nanophotonics and nanoelectronics.

The ANFF difference

Opening the doors to world-class infrastructure is only the first step. Without dedicated staff to support access, breakthrough research remains just an idea. Each ANFF node has experts on hand who are experienced in meeting user requirements and maintaining leading-edge instrumentation to assist researchers. Over 60 technical staff positions are funded through the program. Researchers can either work at the node under expert guidance, or to contract for the fabrication of specialised products at a reasonable cost.

Optofab node of ANFF

Optofab, led by Prof Michael Withford of Macquarie University, consists of four facility centres at Macquarie University, Bandwidth Foundry International, University of Sydney and the University of Adelaide. The headquarters are located at Macquarie University.

Ultrasonic Mill

Funded under the Australian National Fabrication Facility (ANFF), IPAS took delivery of our new DMG Ultrasonic 20 linear 5-axis milling machine. The mill allows machining of glass, ceramics and complex metal objects.

3D Metal and Ceramic Printer

IPAS has a Phenix PXM selective laser-melting printer. 3D printing complements traditional development and manufacturing methods and reduce the time and cost of designing metal or ceramic parts by printing them directly from digital input.

Optofab – Facilities in Adelaide

Optofab – Facilities in Adelaide specialises in optical fibre, glass and functional optical materials production. The range of key services offered include:

- Soft glass fibre fabrication and drawing
- Silica fibre fabrication and drawing
- Microstructured silica preforms and fibres
- Soft glass and polymer preform extrusion
- Soft glass production
- Surface functionalisation of glasses and fibres
- Scanning Near Field and Atomic Force Microscopy (SNOM/AFM)
- Ultrasonic milling
- 3D printing - metal and ceramic

Accessing the Facilities

The ANFF seeks to enhance national and international collaborations and enable world-class research by providing access to specialised facilities. Direct access to instrumentation is provided on an hourly rate or Fee-for-Service basis. Research Collaborations, Contract R&D and Consulting are also welcomed. Dedicated staff are on hand to discuss your requirements, and assist accessing these leading-edge research capabilities.

Contact:
A/Prof Heike Ebendorff-Heidepriem T: +61 (0)8 8313 1136 E: heike.ebendorff@adelaide.edu.au
Mr Luis Lima-Marques T: +61 (0)413 339 808 E: luis.lima-marques@adelaide.edu.au
Prof Andre Luiten obtained his PhD in Physics from the University of Western Australia in 1997, for which he was awarded the Bragg Gold Medal. He has subsequently held three prestigious fellowships from the ARC. For his efforts Andre was the joint inaugural winner of the WA Premier’s Prize for Early Career Achievement in Science. He came to the University of Adelaide in 2013 to take up the Chair of Experimental Physics and a South Australian Research Fellowship from the Premier’s Research and Innovation Fund. He has published over 90 papers in refereed journals and books and raised approximately $13M for research.

A/Prof Heike Ebendorff-Heidepriem is the Facility Manager of the Optotlab node of the Australian National Fabrication Facility (ANFF). Heike obtained her PhD in chemistry from the University of Jena, Germany in 1994 and subsequently held two prestigious fellowships. From 2001-2004 she was with the Optoelectronics Research Centre at the University of Southampton, UK. Heike came to the University of Adelaide in 2005. Heike was awarded the Woldemar A. Weyl International Glass Science Award in 2001 and the International Zwick Science Award in 2009. She has published over 200 refereed journal papers and conference proceedings, including 16 review papers and 9 postdeadline papers, and raised approximately $9M for research.

A/Prof Peter Hoffmann is the Director of the Adelaide Proteomics Centre and Director of the National NCRIS facility for Tissue Imaging Mass Spectrometry. Peter is the Vice President of the Australasian Proteomics Society, Conference Chair for the National Meeting of the Australasian Proteomics Society, and the South Australian Representative of the Australian Peptide Society. Peter obtained his PhD in Analytical Chemistry from Saarland University, Germany in 1999. He came to the University of Adelaide in 2005 to establish the Adelaide Proteomics Centre. He has published over 60 papers in refereed journals and raised approximately $8.5M for research.
For further enquiries

Professor Andre Luiten
Director IPAS
Telephone: +61 (0)8 8313 2359
Mobile: +61 (0)404 817 168
Email: andre.luiten@adelaide.edu.au

Mr Piers Lincoln
Institute Manager IPAS
Telephone: +61 (0)8 8313 0772
Mobile: +61 (0)410 221 278
Email: piers.lincoln@adelaide.edu.au

Associate Professor Heike Ebendorf-Heidepriem
Deputy Director IPAS
Telephone: +61 (0)8 8313 1136
Mobile: +61 (0)439 336 214
Email: heike.ebendorf@adelaide.edu.au

Associate Professor Peter Hoffmann
Deputy Director IPAS
Telephone: +61 (0)8 8313 5507
Mobile: +61 (0)434 079 108
Email: peter.hoffmann@adelaide.edu.au

The University of Adelaide
SA 5005  Australia
www.ipas.edu.au