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Nuclear-based science benefiting all Australians

Bragg Institute

International leader in neutron beam and X-ray science

Foreword

Australia's new world-class research reactor, OPAL, provides a unique opportunity for the nation's scientists to expand their horizons.

OPAL will enhance the nuclear capabilities of the Australian Nuclear Science and Technology Organisation (ANSTO), enabling us to increase the support we provide for Australia's health, environmental and industrial research, as well as the country's strategic objectives.

Since 1958, ANSTO and its forebears have enabled Australian researchers and their counterparts from around the world to use the unique insights afforded by neutron beam science to increase fundamental scientific knowledge and assist numerous industries.

The establishment of the Bragg Institute in 2002 was an essential step towards making such insights more readily available to an increasingly broad range of researchers and industries within Australia and the Asia-Pacific region. We see the opportunity for major growth in areas such as advanced materials, biosciences, the earth sciences and engineering.

Dr Ian Smith
Executive Director, ANSTO

ANSTO IS THE AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION, AUSTRALIA'S NATIONAL NUCLEAR RESEARCH AND DEVELOPMENT ORGANISATION AND THE CENTRE OF ITS NUCLEAR EXPERTISE. ANSTO OPERATES OPAL, A 20 MEGAWATT RESEARCH REACTOR.

Introduction

In a world of increasing technological complexity, our continued prosperity depends in many respects on our understanding of the detailed physical and chemical properties of materials. Neutrons offer an important way to enhance this understanding and their use has contributed to many significant discoveries.

The Bragg Institute leads Australia in the use of neutron scattering and X-ray techniques to solve complex research and industrial problems in many important fields. OPAL will assist in placing the Bragg Institute at the forefront of the world's best neutron research facilities.

The Institute was named in honour of Australians William and Lawrence Bragg, who jointly won the 1915 Nobel Prize for Physics for pioneering the analysis of crystal structures by means of X-rays.

The Bragg Institute combines the principles established by the Braggs and other eminent researchers with the unique capabilities of the new OPAL reactor to the benefit of our customers, the nation and the Asia-Pacific region.

The OPAL reactor is designed to enhance the power and versatility of a wide range of neutron scattering techniques. We are establishing a comprehensive array of state-of-the-art neutron beam instruments for scientific research and industrial applications.

We will also continue to use in-house and external X-ray facilities, including overseas synchrotrons and the Australian Synchrotron, in which ANSTO has an investment.

Much of our work is conducted in collaboration with our users and we pride ourselves on the excellent customer service we offer. Access to neutron beam instruments is by peer review based on merit, with no charge for beam time if results are published in the open literature. Access for proprietary work is available on a fee-for-service basis.

The Bragg Institute has substantial partnerships with other leading research organisations in Australia and is keen to develop more such relationships both within Australia and around the world. We intend to attract new customers from Australia's scientific research community and the business sector.

I trust that this publication will encourage you to consider the benefits that neutron beam science could bring to your own areas of endeavour.

R.O. Robinson

Dr Robert Robinson
Head, Bragg Institute, ANSTO

MATERIALS CASE STUDY ↗

Seeing the future with neutrons

Contact lenses have come a long way since Leonardo da Vinci sketched the concept in 1508.

Originally developed in the 1970s for day wear only, soft contact lenses fit more comfortably on the surface of the eye than do hard contact lenses. Both are made from polymers (plastics).

ANSTO and the Cooperative Research Centre for Polymers are using small-angle neutron scattering and other sophisticated techniques to investigate new polymer materials with high oxygen permeability and superior hydration properties. The aim is to develop materials that will enable contact lenses to be worn for a month or more without discomfort.

Why use neutrons?

Neutrons have many properties that make them useful for studying atomic and molecular structures ranging in size from one nanometre to several hundred nanometres. They can be considered as particles or waves, with wavelengths comparable to the interatomic distances found in solids and liquids. Their energies are of similar magnitude to those associated with molecular vibrations.

Cold (slow) neutrons have low energy and long wavelengths. Thermal neutrons have intermediate energy and wavelengths. Hot (fast) neutrons have high energy and short wavelengths. Neutron techniques can use a single wavelength or a range of wavelengths.

Neutrons have some advantages over X-rays as tools for determining the structure of both molecules and the arrangement of molecules within materials. For example, neutrons can be used to investigate and provide unique information about semiconductors and magnetic materials used in computers.

Unlike electrons and protons, neutrons have no electric charge. This means that they can reveal the position of the nucleus itself, which makes up a tiny fraction of the volume of an atom. In contrast, X-rays are scattered by electrons and reveal the position of the electron clouds.

Heavy atoms scatter X-rays more effectively than light atoms. Neutron scattering varies from nucleus to nucleus. X-rays cannot be used to determine the positions of hydrogen atoms or of light atoms in close proximity to heavy atoms—but neutrons can. Isotopes (atoms of the same element with different numbers of neutrons) such as hydrogen and deuterium can readily be distinguished by neutron scattering but not by X-rays. Scientists can therefore substitute deuterium for hydrogen in polymers and biologically important molecules to highlight particular features by neutron scattering.

As neutrons scatter from nuclei and not electrons, they are highly penetrating. This makes it possible to study samples deep inside large pieces of equipment (such as aircraft engines), and inside vessels that have different conditions of pressure, temperature and environment.

Neutrons behave to some extent like tiny bar magnets and can therefore be used to investigate the magnetic properties of materials such as superconductors and computer memories.

When a neutron beam hits a sample, 80 to 90 per cent of the neutrons pass through the sample, some 'scatter' and a very small number are absorbed. The angle at which the neutron beam hits the sample affects the 'scattering' and, hence, the type of information that can be gained.

Most neutron scattering techniques are based on elastic scattering, in which the energy of the scattered neutrons does not change. Inelastic scattering, in which the energy of the scattered neutrons changes as a result of interaction with the sample, is used to investigate molecular vibrations and magnetic properties.

A new research reactor for Australia

Building a new reactor

ANSTO's new OPAL research reactor will significantly increase Australia's nuclear science and technology capabilities. It will outperform its predecessor, HIFAR, in every aspect, making radioisotope production, irradiation services and neutron beam research quicker and more efficient. The new reactor can operate 340 days a year.

Located on a geologically stable site within a 1.6 kilometre buffer zone, OPAL has been designed to withstand major earthquakes and the impact of large aircraft. Safety features include two independent control systems to quickly shut down the reactor and cool the reactor core in an emergency.

Inside the OPAL reactor

The heart of the new reactor is a compact core of 16 fuel assemblies containing around 20 per cent uranium-235, interspersed with control rods.

The fuel assemblies are cooled by demineralised light water and surrounded by heavy water in a zirconium alloy 'reflector' vessel at the bottom of a 13-metre-deep open pool of light water. The pool is lined with stainless steel and surrounded by a special concrete that contains iron oxides for increased absorption of unwanted radiation. A separate vessel uses liquid deuterium at 20 degrees above absolute zero to produce 'cold' neutrons with lower energies and longer wavelengths.

Neutrons are produced in the heavy water reflector and travel down neutron guides to scientific instruments located outside the reactor containment area. The guides are long, very slightly curved channels of smooth glass with a highly reflective, internal 'supermirror' coating. High-energy neutrons and gamma rays pass through the supermirror surfaces and are absorbed in shielding, while the neutrons with the desired energy bounce off the supermirror sides and continue down the guide channels to the scientific instruments.

Specifications:

Reactor type:	open pool, low enriched uranium, water-cooled
Thermal power:	20 megawatts
Peak thermal neutron flux:	3×10^{14} neutrons per square cm per second in the reflector vessel
Installations:	cold neutron source (20 litres of liquid deuterium at 20K)
	thermal neutron source
	capacity for hot neutron source (graphite at 2 000K)
	irradiation facilities
	silicon transmutation facilities
	guide hall (35 x 65 sq. m)
	up to 18 neutron instruments
Operational:	340 days per year

Mid 2000	neutron beam instruments project commenced
Mid 2005	guide hall and reactor hall ready
Mid 2005	neutron beam operations project commenced
Late 2005	OPAL cold commissioning begins
Early 2006	Bragg Institute building ready
Early 2006	first fuel in OPAL reactor
Late 2006	OPAL reactor and instruments commissioned
Early 2007	HIFAR shut down

Schedule:

Building for the next generation

Bragg Institute Head Rob Robinson says the new reactor is "the opportunity of a generation." With an impressive track record in condensed-matter physics in five countries, Dr. Robinson clearly relishes his role as one of the founders of a facility he says will "create an environment on which Australia can live for 20 years." His own research interests have been set aside while he concentrates on "building something big and useful" that will meet the needs of the future.

Despite the organisation's relatively small size, Robinson believes ANSTO has the right culture to place the new reactor and its neutron beam instrumentation among the world's top three such facilities. "And in some areas, such as time-resolved powder diffraction and small-molecule crystallography, we will be the world's best."

The Bragg Institute

Past, present and future

In 1915, father and son team William and Lawrence Bragg became Australia's first winners of the Nobel Prize for Physics, which they were jointly awarded for their work in founding a new branch of science of great significance and importance—the analysis of crystal structure by means of X-ray diffraction.

In 2002, ANSTO established the Bragg Institute to maximise scientific use of the new OPAL reactor and named it in honour of the Braggs.

Neutrons and X-rays are complementary tools for investigating molecular structures and properties. The Bragg Institute is the leading group in Australia in the use of neutron scattering and
X-ray techniques to solve complex research and industrial problems in a wide range of fields including plastics, minerals, engineering, pharmaceuticals, electronics and biology. Bragg Institute staff are responsible for the design and implementation of the initial suite of eight neutron beam instruments that will utilise the full capabilities of the OPAL reactor.

- QUOKKA: small angle neutron scattering (polymers, colloids, superconductors, defects, biology)
- PLATYPUS: reflectometer (surface science, interfaces, complex fluids, magnetic films and multi-layers)
- ECHIDNA: high-resolution powder diffractometer (materials science, chemistry, geosciences)
- WOMBAT: high-intensity powder diffractometer (in-situ measurements, chemistry)
- KOALA: quasi-Laue diffractometer (chemical crystallography, protein crystallography)
- KOWARI: residual-stress diffractometer (engineering)
- TAIPAN: thermal 3-axis spectrometer (condensed-matter physics)
- Time-of-flight/polarisation-analysis spectrometer (magnetism, condensed-matter physics)
- Cold 3-axis spectrometer – funded by National Science Council, Taiwan (magnetism, condensed-matter physics)

The Bragg Institute has in-house X-ray reflectometry and small-angle X-ray scattering instruments and an excellent range of ancillary equipment. Staff are developing integrated computer systems for everything from applications for beam-time to use the instruments, through to final analysis of experimental data.

Under the leadership of Dr Rob Robinson, the Institute is working to increase its partnerships with other leading research organisations in Australia and around the world. The Institute also wants to attract potential new users from Australia's scientific research community and the business sector.

Australian Neutron Beam Users Group

Realising the full potential of the Bragg Institute and the OPAL reactor will require more than just world-class neutron beam instrumentation. It will also require people to make the best possible use of these facilities.

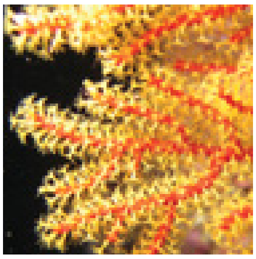
The Australian Neutron Beam Users Group (ANBUG) is helping to ensure that the Bragg facilities address the needs of the majority of potential users and that attention is paid to other important issues such as access, security and sample environments.

Outgoing ANBUG president Dr Ian Gentle, from the University of Queensland, says the group is actively developing ways to make it easier for new users to use neutron scattering techniques. Their website is at www.anbug.org

THE BRAGG INSTITUTE

Support for synchrotron research

The Bragg Institute is home to the Australian Synchrotron Research Project, which is funded by the Federal Government to provide Australian researchers with merit-driven access to state-of-the-art synchrotron radiation research capabilities at overseas facilities. ANSTO has also invested $5 million in the Australian synchrotron facility being built in Melbourne. Synchrotrons produce very intense, highly focused X-ray beams.



BIOPHYSICS CASE STUDY ↗

Crab shells for stem cells

A substance derived from chitin—a natural polymer found in lobsters, shrimp, crabs, coral and jellyfish—could literally provide the foundation of a new treatment for damaged or diseased nerve tissue.

Chitosan is a polysaccharide made from chitin, the world's second most abundant natural polymer. A liquid at room temperature, it forms a gel-like scaffold at body temperature, and could potentially support the growth of stem cells being used to repair diseased or damaged human tissue.

ANSTO and Monash University are using small- and ultra small-angle neutron scattering to study the formation and structure of the three-dimensional chitosan scaffold.

NEUTRON GUIDE

Since neutron scattering first captured his imagination, Bragg Institute Technical Director Shane Kennedy has spent over 20 years using polarised neutron techniques, neutron diffraction and neutron optics to study solids and liquids in Australia, Europe and Asia.

Dr Kennedy currently leads the team that is building the OPAL reactor's highly-specialised neutron scattering instruments and neutron beam transport system.

Educated in Melbourne, Sydney and London, Kennedy has worked in physics, materials science and medical science. When OPAL goes live in 2006, he will combine management responsibilities with a mentoring role for scientists using several of the Bragg Institute's key neutron scattering instruments.

QUOKKA:

small-angle neutron scattering

Small-angle neutron scattering (SANS) is a highly versatile technique for investigating a wide range of materials including polymers, emulsions, colloids, superconductors, porous media, geological samples, alloys, ceramics and biological molecules such as proteins and membranes.

When a neutron beam hits a sample, some neutrons scatter along a path that differs from the transmitted beam by as little as several hundredths of a degree. This 'small-angle' scattering provides information about relatively large structural details between one and 100 nanometres.

Potentially, one of the world's top two SANS instruments, QUOKKA will accommodate specialised equipment for controlling the sample environment (e.g. temperature, pressure, magnetic field). It can collect data over a wide range of angles and offers a choice of combinations of beam intensity and angular resolution. Magnetic materials can be studied by SANS using polarised neutrons.

In addition to its fundamental research uses, the technique is a unique source of valuable information for the polymer, food and petrochemical industries.

PLATYPUS:

neutron reflectometry

Neutron reflectometry provides information about the composition of thin films and surfaces as a function of depth. It is particularly useful for studying surfaces, buried interfaces, complex fluids, magnetic films, multi-layered structures and processes that occur at surfaces and interfaces.

The technique involves the reflection of a neutron beam from the surface of a sample at angles less than a few degrees. Above the 'critical angle' (which depends on sample composition), some neutrons are reflected while most are transmitted. The measured data are compared with calculated reflectivity data based on one or more structural models.

Because PLATYPUS uses many wavelengths simultaneously and scans only a small number of angles, data collection is fast and the instrument can be used to look at how surface characteristics change over time.

PLATYPUS will be one of the world's top five neutron reflectometers with the additional feature of being able to study films on free-liquid surfaces.

Neutrons for Biology

Twentieth century advances in the physical sciences have helped to advance biology to a very exciting stage by providing tools for studying the finest details of the structures of the giant molecules that sustain life: proteins and DNA.

Australian-born biophysicist Jill Trewhella has been using neutrons to study biological molecules for more than two decades, mainly in the USA. Since 1980, she has pursued her research at Yale University, Los Alamos National Laboratory and the University of Utah.

A five-year Australian Federation Fellowship at the University of Sydney has brought Trewhella back home. Working with researchers at the Bragg Institute, she will study how signals are transmitted inside cells during processes such as the adrenalin rush that helps us react to a threat. These signals are sent via small messenger molecules that bind to and modify the structures of specific proteins in order to elicit the response needed.

Trewhella's research seeks to improve human health. For example, her research on the signals that control muscle contraction aims to identify targets for drugs that could be used to treat life-threatening heart conditions.

Trewhella says the Federation Fellowship is a rare opportunity for her to set aside a heavy administrative workload and concentrate on research.

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POLYMER CASE STUDY ↗

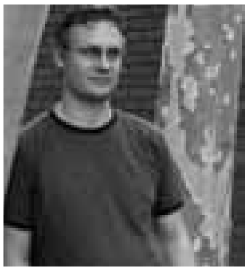
Scientists hit the bottle — with X-rays

X-rays are helping to solve the mystery of why the PET (polyethylene terephthalate) bases of some carbonated soft drink bottles fail when the bottles are stored at high temperature and humidity levels.

ANSTO and a partner from the Cooperative Research Centre for Polymers used small-angle X-ray scattering techniques to look at the polymer molecules that make up the base of a PET bottle.

In some cases the polymer molecules were lined up rather than tangled together, potentially making the bases weak enough to fail under the pressure required for carbonated soft drinks to keep their fizz.

The X-ray findings could help bottle manufacturers eliminate the problem.



SMALL ANGLE, BIG PICTURE

Bragg Institute staff member Jamie Schulz combines a high level of expertise in small-angle neutron scattering and neutron reflectometry with solid experience in instrument operation and customer support services.

Educated in Adelaide and Sydney, Dr Schulz worked at neutron scattering facilities in the US before joining ANSTO in 2002.

Schulz is keen to use his small-angle neutron scattering and reflectometry expertise to "help neutron beam customers obtain the high quality data they need to achieve their research goals" when the OPAL reactor goes live in 2006.

ECHIDNA:

high-resolution powder diffractometer

High-resolution powder diffraction is used in many fields, including solid-state physics, materials science, chemistry, geoscience and engineering.

The technique uses a single wavelength and a highly collimated beam of neutrons to improve resolution. It is ideal for determining small changes or fine structural details that can have a significant impact on electronic, magnetic or mechanical properties.

ECHIDNA will be one of the world's top two reactor-based high-resolution powder diffraction facilities. Special features include the ability to undertake stroboscopic studies with changing parameters, i.e. to take millisecond 'snapshots' of structural data for both periodic and irreversible changes.

WOMBAT:

high-intensity powder diffractometer

High-intensity powder diffraction is a fast way to obtain a rough picture of a crystalline structure. Potentially the world's fastest reactor-based neutron powder diffractometer, WOMBAT will be able to collect enough data for a single structure in a matter of milliseconds.

The technique is ideal for rapid, real-time, in-situ measurements of chemical and metallurgical processes such as those involved in synthesising new materials.

Other uses include surveying the structural properties of materials over a wide range of conditions and environments such as high-pressure cells. WOMBAT can also measure samples with more 'random' atomic structures, such as liquids and glasses.

Neutron diffraction

Neutron diffraction techniques use the patterns that result when neutrons scatter from a crystalline material (i.e. one with a structure that consists of regular repeating units) to determine the arrangement of atoms and molecules within that structure.

Powder diffraction is particularly useful for naturally polycrystalline materials or where single crystals of the required size are difficult to obtain. The technique can resolve structures very accurately (high-resolution powder diffraction) or make very rapid measurements of systems undergoing change (high-intensity powder diffraction).

Structures that have been determined by powder diffraction include superconductors, pharmaceutical drugs, aerospace alloys, catalysts, organic compounds, cements, minerals, zeolites, hydrogen storage media and optical materials.

Quasi-Laue diffraction is ideal for determining the complex crystal structures of a wide range of chemicals, minerals and biological molecules.

The Bragg Institute's diffraction instruments accommodate a range of sample environments including wide variations in temperature, pressure, magnetic and electric fields.

Structures that have been determined by powder diffraction include superconductors, pharmaceuticals, alloys, cements, minerals and optical materials.

ENGINEERING CASE STUDY ↗

Powerful stress relief

Turbine blades in power stations operate at almost supersonic speeds near the blade tips, making the leading edges of the blades susceptible to damage by water droplets condensed from steam.

Replacing prematurely-worn turbine blades is expensive, but an onsite refurbishment technique called laser cladding has the potential to save power stations as much as $1 million per turbine.

Laser refurbishment with Stellite®, a hard-wearing cobalt/chromium alloy, offers several advantages but can lead to residual stress problems. Using neutron and X-ray diffraction techniques, ANSTO and other groups have shown that a post-welding heat treatment helps to overcome these problems.

ANSTO's contribution involved using 'strain scanning' techniques to measure residual stresses and assess the potential for premature failure.

X-RAY EXPERTISE

Tracey Hanley says she loves a challenge. As scientist in charge of the Bragg Institute's X-ray reflectometry and small-angle X-ray scattering (SAXS) instruments, Dr Hanley particularly enjoys working on "real-life applications with clearly defined benefits."

The two X-ray techniques complement ANSTO's equivalent neutron scattering techniques and will appeal to users who want to apply X-ray and neutron techniques to the same samples.

X-ray reflectometry is used to investigate thickness, density and surface roughness in flat films between one and 100 nanometres thick, such as those found in anti-reflective coatings and biologically active surfaces.

The SAXS instrument is useful for examining the intrinsic properties of bulk materials such as colloids, solutions, polymers and ceramics. It enhances ANSTO's strong in-house polymer science capabilities. SAXS is also particularly useful in correlating food taste and texture with microstructure.

KOALA:

quasi-Laue diffractometer

Single-crystal neutron diffraction studies complement X-ray crystallography by revealing the precise positions of light atoms such as hydrogen. The highly-accurate structural data produced by these techniques have revolutionised many areas of science.

The KOALA diffractometer can readily determine crystal structures for single crystals with a volume of just one-tenth of a cubic millimetre. On average, data collection will take less than a day per sample. Multiple temperature and pressure measurements can be undertaken on a single crystal.

KOALA will enable the Bragg Institute to become one of the world's best small-molecule crystallography facilities.

KOWARI:

residual-stress diffractometer

Designed in collaboration with potential university and industrial users, the KOWARI residual-stress diffractometer can be used for 'strain scanning' of large engineering components up to 1000 kilograms. Sample positions can be located to within 10-20 micrometres (the width of a fine wool fibre) and one-thousandth of a degree of rotation.

In addition to its engineering applications, strain scanning can also be used to investigate new materials such as shape-memory alloys and new processes such as friction stir welding. Shape memory alloys can return to their original shape after bending or deformation and are used in medical and aerospace applications. Friction stir welding uses the heat generated through friction from a rotating tool to plasticise and join together two surfaces.

KOWARI will service the needs of the Asia-Pacific region.

Neutrons for engineering

Welding, casting and forging techniques may create strains, distortions and residual stresses that can significantly reduce the life of important structural and engineering components. Some residual stresses can be beneficial, but still need to be monitored and controlled.

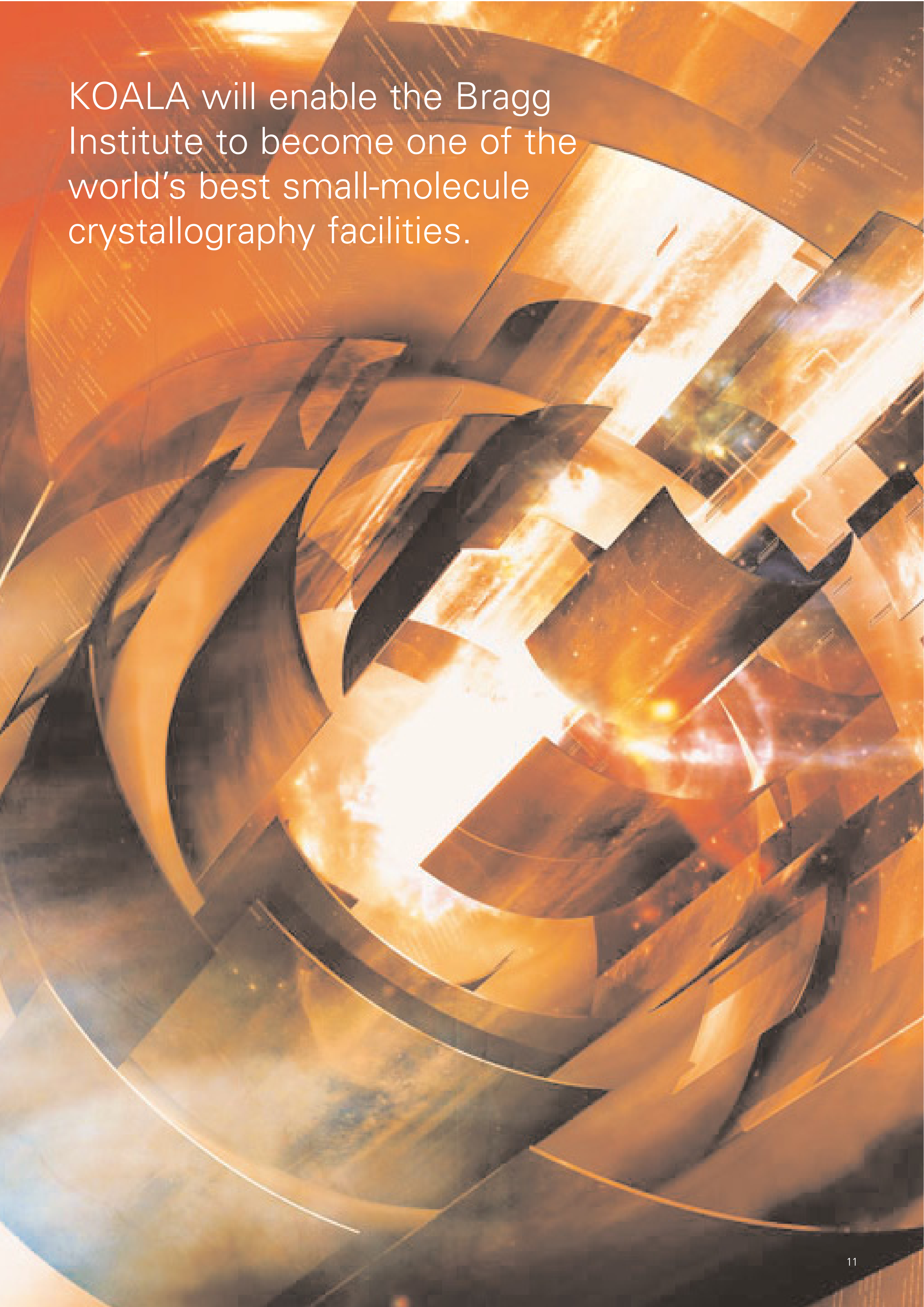
Using a residual-stress diffractometer for 'strain scanning' can identify problem areas and make it possible to extend the serviceable life of these costly structures. Because the technique is non-destructive, it can be used for ongoing monitoring of a component's condition.

Neutron strain measurements are assisting the development of new friction-based welding techniques and leading to increased use of post-welding heat treatments that reduce residual stresses brought about by welding.

Strain scanning provides information on internal micro-mechanical properties that cannot be obtained by any other method. This information can be used to develop improved composite materials or to refine and validate the models used to design and assess engineering structures.

The technique has been used to investigate how the failure of wheel and rail materials has contributed to railway disasters, and to assist the development of welded structures for large aircraft that could rival the new A380, the world's largest passenger plane.

KOALA will enable the Bragg Institute to become one of the world's best small-molecule crystallography facilities.



MATERIALS CASE STUDY ↗

Networking with polymers

Polymers can be combined in much the same way as metals are mixed to make an alloy. Uses for these multi-component polymer materials include tyres and artificial teeth.

The trick is to persuade the different polymers to form three-dimensional molecular networks with the best combination of individual properties. For example, mixing a strong but brittle polymer (such as polystyrene) with a rubbery polymer (such as polybutadiene) could create a very tough material for automotive bumper bars.

ANSTO, the University of NSW and the Cooperative Research Centre for Polymers are using X-ray and neutron techniques to help them tailor the properties of interpenetrating polymer networks for particular applications.

A NEW ANGLE ON BIOLOGY

ANSTO is using neutron and X-ray scattering techniques such as small-angle scattering and reflectometry to study the relationship between the shape of biomolecules and how they work. For example, small-angle neutron scattering is being used to reveal how tiny photosynthetic algae called diatoms create their ornate silica structures. The communications industry is interested in the luminescence properties of these structures.

Neutron techniques are helping ANSTO and the University of Sydney find out whether crocodile blood cells could hold the key to making human blood substitutes. ANSTO is also studying sol-gel biocatalysts, in which enzymes are immobilised in silica gel cages, and investigating how water influences the behaviour of cellulose in paper.

The value of neutron studies can be maximised by using deuteration, a process that involves substituting hydrogen atoms with deuterium atoms. Because neutron scattering can distinguish between hydrogen and deuterium (a hydrogen atom with an added neutron), deuteration can be used to highlight particular sections of a sample or molecule. ANSTO has expertise in the deuteration of biopolymers and other biomolecules.

TAIPAN:
triple-axis spectrometer

When a neutron beam penetrates a sample, the neutrons can create or annihilate collective oscillations (phonons) in the sample's atoms. By determining how much energy has been lost or gained by neutrons in the scattering process, the triple-axis spectrometer provides information on interatomic forces and the movement of atoms in the sample.

The technique is based on principles pioneered by Professor Bertram Brockhouse from McMaster University in Canada, who shared the 1994 Nobel Prize for Physics for his contribution to the development of neutron scattering techniques. It is particularly useful for testing models of interatomic forces in condensed-matter physics.

Because it has to measure very weak signals, TAIPAN has been designed to maximise the number of neutrons that reach the sample. Potentially it will be one of the world's two top thermal-beam triple-axis spectrometers.

Time-of-flight/polarisation-analysis spectrometer

In a polarised neutron beam, all neutrons have the same magnetic direction. Measuring the changes in magnetic direction that occur when a polarised beam of neutrons scatters from a magnetic sample provides information on the sample's magnetic and electronic characteristics.

Time-of-flight polarisation analysis spectrometry is particularly useful for studying magnetic materials (such as those being developed for new electric motors or digital storage devices) and superconductor materials. A time-of-flight instrument measures energy changes by timing neutrons travelling between fixed points.

This instrument will be one of only three or four in the world that can simultaneously make accurate measurements of tiny changes in the magnetic polarisation and energy of neutrons. It is expected to appeal to university researchers interested in physical and chemical properties and some industrial applications.

Inelastic scattering

Many neutron scattering techniques are based on elastic scattering, in which the energy of the neutrons does not change. Inelastic scattering occurs when the energy of the neutron changes as a result of interaction with the sample.

Triple-axis spectrometry and time-of-flight polarisation analysis spectrometry use inelastic scattering to investigate molecular vibrations and magnetic properties. These highly-sensitive techniques can provide information not accessible by any other means.

ANSTO caters for neutron-beam users with many different needs and levels of expertise. Bragg Institute staff can assist with every step from sample preparation to comprehensive data analysis or simply provide data that advanced users can interpret for themselves

Research assistance

ANSTO caters for neutron-beam users with many different needs and levels of expertise. Bragg Institute staff can assist with every step from sample preparation to comprehensive data analysis or simply provide data that advanced users can interpret for themselves.

Associate Professor Brendan Kennedy from Sydney University is a frequent visitor. He says ANSTO staff "advise users how to get the best possible results from the instrumentation."

Kennedy and PhD student Rene Macquart recently used ANSTO's high-resolution powder neutron diffraction services to solve a 50-year mystery surrounding a layered bismuth oxide, $SrBi_2Ta_2O_9$.

Layered bismuth oxides have potential uses in the next generation of ferroelectric devices such as computer memories. However, the performance of thin films is reduced when they are annealed above the temperature at which the material changes from ferroelectric to paraelectric.

Kennedy combined group theory with variable temperature neutron diffraction studies between room temperature and 1 000°C to establish the presence and determine the structure of a previously unknown intermediate phase.

How to find out more about the Bragg Institute and ANSTO

The Bragg Institute is happy to provide further information on our facilities, services, research programs and publications.

In addition to our own neutron scattering and associated X-ray facilities, we can also offer Australian researchers from industry and the private and public research sectors access to overseas facilities. This is done through the Australian Synchrotron Research Program (www.ansto.gov.au/natfac/) and the Access to Major Research Facilities Program (www.ansto.gov.au/natfac/amrfp/).

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