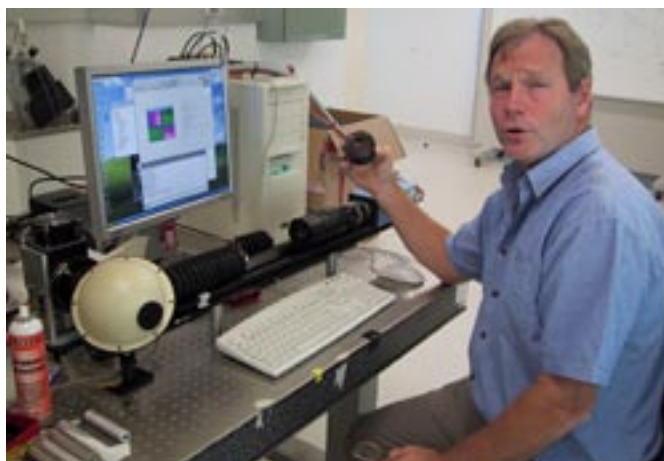


## See the light - know the temperature

by David Salt

How do you measure the temperature of a substance so hot that it would melt any probe placed near it? This is an issue that has long challenged plasma physicists working on fusion energy.

Fusion involves heating up plasma (ionised gas) to millions of degrees to enable hydrogen atoms to fuse and form helium atoms. In so doing this fusion releases energy. The super hot plasma is contained within a powerful magnetic bottle as no known material could withstand the extreme temperatures without melting. Understanding how to control such a process requires a detailed understanding of what the plasma is doing – how is it flowing



*Dr John Howard with one of the electro-optic components that lie at the heart of the new coherence imaging system. The system allows researchers to better measure the temperature and flow of a plasma by analysing the light it emits.*

and what is its temperature. But how do you measure this if you can't physically get close to it?

The answer lies in analysing the light being emitted by the plasma. When excited plasma ions emit

light, the colour depends on the motion of the particle relative to the observer (the well known Doppler effect). It is possible to estimate the ion velocities (hence temperature) by analyzing the spread of colours.

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<http://ni.anu.edu.au>

## Koalas prefer large trees

The way that koalas in the wild distinguish between thousands of types of potentially nauseating tree leaves when eating has been revealed by ANU researchers.

In the same way that humans learn to avoid foods that make us ill, koalas also learn from experience what to eat and what to avoid, according to research published by Dr Ben Moore and Professor Bill Foley from the ANU School of Botany and Zoology in the latest edition of *Nature*.

"Fortunately for bushwalkers, the koalas' learned association between nauseating toxins and the smell of certain leaves means they don't become physically sick," Dr Moore said.

The researchers mapped the content of nutrients and toxins in every tree in an area of forest on Victoria's Phillip Island.

"Although we already knew that a particularly sickening group of toxins controls how much koalas



Ben Moore

*Researchers found that koalas prefer larger trees because they provide more food and shelter and a greater chance of interaction with other koalas.*

continued next page

## Koalas prefer large trees

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eat in captivity, koalas in the wild have many more choices and have to contend with predators, changing weather and the need to keep in touch with each other," Dr Moore explained.

"It's like having to choose between 1000 restaurants (or trees in the koalas' case), spread all over town, without a restaurant guide."

By combining their map with data collected by the local Friends of the Koalas group over 10 years, the researchers found that koalas prefer larger trees — which provide more food and shelter and a greater chance of interaction with other koalas.

"However, among these large trees, they avoid those that have leaves with an excess of nauseating toxins and trees with leaves that contain little protein," Dr Moore said.

Dr Moore said the research should inform conservation of trees, based on whether they are an important food source for animals.

"Plant chemistry restricts the use of trees by koalas, and thus limits the food available to koalas and potentially influences koala populations," he said.

"Our results show that what simply looks like a patch of forest to us can actually be a complicated mosaic of good and bad food patches for wildlife. Some trees can largely escape being eaten while some particular trees are especially important food resources.

"This reinforces the need to conserve large old trees for all wildlife, not just those species that use hollows for nesting.

"Large trees can take hundreds of years to grow and their loss through logging or just old age reduces both the amount of food available for leaf-eating animals, like the koala, and also limits their ability to choose the highest quality diet possible."

Dr Moore undertook the research as part of his PhD at ANU with Professor Foley. Dr Moore is currently a post-doctoral fellow at James Cook University.

# Mutant gene and diabetes

A new gene suspected to contribute to autoimmune diseases such as type 1 diabetes and lupus — a condition in which the body's own immune system attacks organs such as the kidneys and skin — has been discovered by ANU immunologists.

The researchers found that a mutation in the gene, which they have named Roquin, causes the body's infection fighters — T-cells — to attack their own tissue; the realisation opening the way to explore treatments that target the mutation.

Studies of the gene are underway in patients with lupus — which affects one in 700 women of childbearing age — and type 1 diabetes to determine whether the same or similar mutations observed in laboratory mice are present in humans.

"This could reveal other abnormalities that underpin autoimmunity, and open up opportunities for developing specific treatments and drugs," said lead researcher Dr Carola Vinuesa, from the John Curtin School of Medical Research (JCSMR) at ANU.

The discovery of Roquin was revealed in the latest edition of *Nature* magazine.

The researchers mirrored the spontaneous genetic variation that occurs naturally during population growth by introducing random changes in the mouse genome, generating novel models of autoimmune disease. After identifying signs of lupus, they worked backwards to find the altered gene responsible for the condition.

"Before this study, the existence and function of Roquin was not known. However, we now know that in the immune system of mammals, the protein Roquin usually suppresses the activity of forbidden T-cells that bind to parts of the body.

"We found that a single mutation in Roquin causes these T-cells to be abnormally activated, and results in autoimmunity affecting many different parts of the body," Dr Vinuesa said.

Autoimmune disease occurs when the immune system is activated to mount a response against normal tissue in the body, treating it as if it were a germ and damaging and destroying the tissue. For example, in type 1 diabetes,

an immune response is mounted against the insulin-secreting cells of the pancreas; in lupus, virtually any part of the body can be attacked by the immune system.

According to Professor Christopher Goodnow, the Head of the Immunogenomics Laboratory at JCSMR and Director of the Australian Phenomics Facility, the discovery hinged upon identifying a single letter change in the DNA code of Roquin.

"It's one very small part of the genome that has proven a very big breakthrough. That single nucleotide change reduces the function of an autoimmunity gene and protein that was hitherto entirely unknown.

According to Professor Goodnow, the characteristics of the Roquin protein suggest that it might repress immune cells by silencing the communication channel between genes and cell functions.

"Roquin stops T-cells from displaying a stimulatory receptor, ICOS, that may cause the cells to attack normal body tissues. Therefore this gene seems critical in protecting us from autoimmunity — but it only takes the mutation of one letter in that gene to cripple its function and lead to autoimmune disease.

"This finding immediately opens up research into testing the function of Roquin, examining variants that may explain autoimmune disease and working towards discovering drugs that might increase or decrease the activity of the newly-realised process."

The discovery was part of a research program into autoimmune diseases by the JCSMR, the Australian Phenomics Facility, the ANU Medical School and Oxford Uni, Professor Goodnow said.

"The specific work described stems from a program between ANU and Oxford University, and its intersection with a separate Juvenile Diabetes Research Foundation and National Health and Medical Research Council special program in diabetes.

"These represent ambitious efforts to pioneer a new way to connect genes with immune system control mechanisms in diseases such as systemic lupus erythematosus and type 1 diabetes."





## Smoking fire

This is a snapshot of a thermally unstable, two-dimensional hypersonic shock wave at Mach 15 with density perturbations, computed at the ANU Supercomputing Facility.

A physical understanding of the role of thermal and dynamical instabilities is critical to many classes of astrophysically interesting radiative shock waves, which occur in high-redshift radio galaxies, supernova

remnants, and the jets associated with newly born stars, among other environments.

Colour represents the temperature of the gases, from 600,000 K down to 10,000 K.

The image was provided by Dr Ralph Sutherland from the Research School of Astronomy and Astrophysics, and appeared Sutherland, R.S., Bicknell, G.V. & Dopita, M.A. 2003 The numerical simulation of radiative shocks. II. Thermal instabilities in two-dimensional models *Astrophys. J.*

591(1), 238–257.

This image also appeared as part of *flowvis*, an exhibit showcasing the amazing world of fluid dynamics. *flowvis* was staged in the ANU School of Art at the beginning of February (as part of the 16th Biennial Congress of the Australian Institute of Physics). *flowvis* was conceived and produced by Melanie O'Byrne, a doctoral student at the Research School of Earth Sciences. It is now touring around Australia.

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*Professor John White (RSC), Professor Tony Haymet, Chief, CSIRO Marine Research and Professor Kurt Lambeck (RSES) at the PMSEIC presentation in March.*

## Ice cubes from Antarctica

by Christine Denny

Not many people can boast the pleasure of consuming water which has been cooled by 500,000 year-old ice cubes, however, this is exactly what the Australian Prime Minister experienced during a presentation on the *Opportunities for Antarctic and Southern Ocean Science* as part of a Prime Minister's Science, Engineering and Innovation Council (PMSEIC) meeting. The ice, taken from an Antarctic glacier, was transported from Antarctica to Canberra, exclusively for the meeting by the working group presenting to the PM.

Professor John White from the University's Research School of Chemistry was Chair of the

International Steering Committee for the review of Australia's Antarctic Science programme in 2003. That report went to the Antarctic Science Advisory Committee (ASAC) and the Minister of the Environment. In March 2005 a working party made a presentation to the PMSEIC, which focused on *Research Advancing Australia's Antarctic Interests*. The recommendations



of the ASAC Report included the need for additional younger researchers to be located in Antarctica, particularly within the

## Light and temp

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While there's nothing new about measuring temperature from radiated light (astronomers have been measuring the temperature of distant stars this way for many decades) scientists at the Plasma Research Laboratory in the Research School of Physical Sciences and Engineering have devised a radically improved method by targeting the optical coherence of the emission. For simple colour scenes, imaging of the phase and amplitude of the optical coherence (interferogram) at one or more optical delays can be used to efficiently capture the key parameters, like temperature or flow, that shape the colour scene.

"Our new spectrometer uses electro-optic and novel quadrature polarization-interferometric techniques to allow high-throughput, high-spectral-resolution colour imaging," says Dr John Howard, the scientist leading the research.

"The coherence images can be recorded either using successive camera frames synchronised with electro-optic path-length modulation

methods, or by statically segmenting the image so as to display dc and quadrature pieces of information in a single frame."

"The technique has been patented and we've already sold this system to several major labs around the world."

Not only has this approach produced a significantly better system for diagnosing plasmas involved in fusion research, it looks like it may also have some important industrial applications. When the temperature of a body increases, the primary colour of the light that it radiates shifts towards the blue. For example, as a simple filament heats up, its colour changes from dull red through to brilliant white, and there are a range of spectroscopic techniques that allow you to determine the temperature of the filament based on the strength and colour (or wavelength) of the emitted light. Colour-based methods are used in steel making for estimating the temperature of the molten iron streaming from the taphole at the bottom of a blast furnace. However, present methods suffer uncertainties in the presence of slag, which can

also flow from the furnace.

"For efficient process control, it's important to know when the slag starts to flow," says Dr Howard.

"However, it's not easy to spot. As with plasmas, remotely measuring the temperature and constitution of these extremely hot materials is challenging. Nevertheless, it looks like our quadrant optical coherence imager may provide a better solution by allowing us to distinguish between the slag and iron based on the difference in their colour and brightness signatures."

With funding support from Bluescope Steel and the ACT Knowledge Fund, a research collaboration to develop the imaging system is currently underway.

More info: [John.Howard@anu.edu.au](mailto:John.Howard@anu.edu.au)

## Antarctic ice cubes

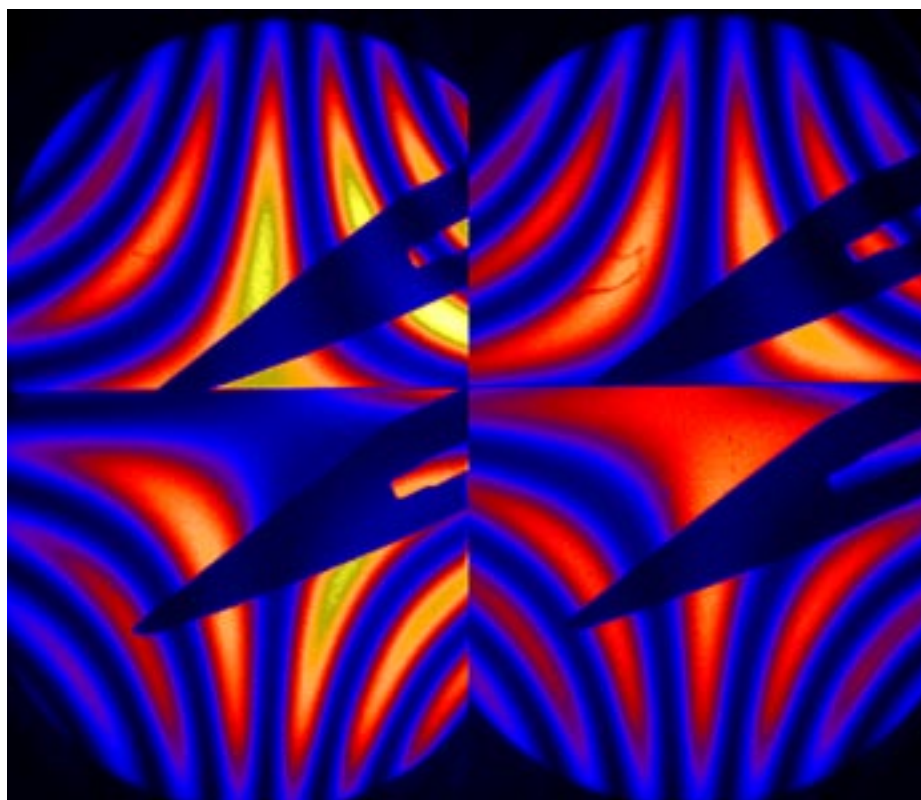
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fields of Earth science, chemistry and bioprospecting; an air transport system from Australia to Antarctica; and a leadership role in developing and implementing a Southern Ocean observation and data-gathering system. Observational data collected from Antarctica and the Southern Ocean is crucial to a range of environmental issues including weather forecasts across the globe.

A variety of opportunities were identified by the report. These included the prediction of the likelihood and extent of sea-level rise caused by the melting of Antarctic ice sheets; the protection of resources and environment by better understanding Antarctic and Southern Ocean biodiversity; better management of Southern Ocean Fisheries through knowledge of the ecosystem; and obtaining a share of the world's next generation of optical/infrared telescopes. Tourism, greater international collaborations and enhancing scientific activity for the 2007 International Polar Year were also highlighted.

In May, Environment Minister, Senator Ian Campbell announced that the Australian Antarctic Division would receive \$46 million towards the establishment of a Hobart - Antarctica Air link to Antarctica. Test flights are to begin in 2006.

"This is a very good outcome," commented Professor White.



*An example false-colour 4-quadrant image of the interference fringes produced by the birefringent optical delay plates at the heart of the new coherence imaging system. The fringes appear when the system is illuminated by a uniform monochromatic light source. While the interference patterns in each image are subtly different, a scalpel blade in the field of view illustrates the essential imaging properties of the system.*



# Rich new stamping grounds

by David Salt

Researchers in the Department of Engineering are investigating whether a promising group of fibre metal composites might be suitable for stamping into car parts. The composite materials are known as fibre-metal laminates or FMLs, and they are composed of sheets of light-weight metal with a layer of fibre composite in between.

"FMLs aren't new," says Mr Luke Mosse, a PhD student leading the research. "They've been around for over a decade. They were originally developed as aerospace materials which were light and strong, and exhibited excellent fatigue resistance.

"Unfortunately, these original FMLs used thermoset polymers as the fibre composite layer sandwiched between the metal layers. Thermoset materials such as epoxy set on heating and then stay in that shape (even if reheated). This makes the creation of complex shapes difficult and expensive."

"In recent years researchers in the Department of Engineering have developed a range of new FML composites using thermoplastic polymers instead of the traditional epoxy as the core layer in between sheets of aluminium.

"Unlike thermoset polymers, thermoplastic polymers can be reformed when they are heated," explains Mr Mosse. "This means we can create flat sheets of this material and then, with the application of a bit of heat, stamp complicated shapes into them.

"It's not enough to come up with new super-strong composite materials. They also need to be suitable for the mass production environment, and that means metal stamping. My research is focussed on understanding how two different FML systems perform under a range of stamping conditions."

To create sheets of FML the researchers place sheets of the fibre-reinforced composite between two thin sheets of aluminium. The total layered sandwich is then put into a heated press and fused together to form a light, thin, high-strength plate.

*Luke Mosse with two test stampings of the new fibre metal laminates. Different fibre composites perform in very different ways.*

"Creating sheets of FML is relatively straightforward and could easily be scaled up for industry," says Mr Mosse. "Pressing that sheet into different shapes in a reliable and predictable fashion, however, is a more challenging proposition because little is known about how they will respond to stamping. Each layer in the FML has its own properties and the manner in which the system as a whole behaves depends on all of these plus what's happening in the critical interfacial zones between the layers."

To explore how the two FML systems perform Mr Mosse is carrying out a series of investigations on what happens to the FML when stamped at different temperatures, pressures and speeds. He then models the various components making up the different systems and measures the forces at work during the stamping process.

"This type of work is a mix of data collection, computer modeling and then testing and more data collection," says Mr Mosse. "The aim is to create an understanding of how the FML system is working so that you can predict with confidence how it will perform under a range of standard operational conditions experienced in the stamping process. We're still building the model at the moment but results so far suggest there's enormous potential for these FMLs to be used in mass manufactured stamping systems."

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*Ancient zircons found in the Jack Hills, Western Australia (pictured here) are reshaping our view of early Earth.*

## Not so hellish

The very earliest years of Earth have long been presumed hot, violent and terrible – so much so that the era from 4.5 billion years to 4 billion years ago is known as the Hadean Eon, or Hellish time.

However, a four-year study of the oldest known minerals on Earth, published earlier this month in *Science* magazine, has found that Hadean is most probably a misnomer. Research by ANU Geologist Professor Mark Harrison and Professor Bruce Watson from the US Rensselaer Polytechnic Institute found that rocks were formed in a controlled, ordered manner in the early Earth.

"It's been an article of faith that the Hadean period was a hellish time, but it's time to come up with a new name," Professor Harrison said.

"Theorists have traditionally painted the early Earth as a hellish, desiccated place, suggesting rocks on Earth would have been formed as a result of frequent impacts of meteorites. However, this would have produced rocks that were formed at very high temperatures and bone dry – but we found the opposite. This wasn't a time of chaos. Rocks were made in a controlled and ordered way, in many ways similar to the modern era.

"The chances are that if you showed up for an afternoon on the early Earth you would have seen blue oceans and sky, continents sticking out with roughly the same mass that we have today."

The researchers devised a unique method of assessing the temperature at which rocks formed, by examining titanium content in zircons - small crystals that are created during rock formation. While the ancient rocks themselves have eroded, small quantities of the ancient zircons were



## Yes, but what does it mean?

On 16 May, 1968, His Royal Highness Prince Phillip, Duke of Edinburgh, officially opened the Forestry Building, which was to be the permanent home of the first full Department of Forestry to be established at an Australian university. He is pictured pondering the massive wooden wall

sculpture that adorns the entrance foyer of the building.

Carved out of laminated blackwood (*Acacia melanoxylon*), the sculpture symbolises the growth of a tree seed. It was created by the famous Lithuanian born Victorian sculptor, Vincas Jomantas.

To the right he is pictured viewing some of the research being undertaken in the department.



Photos courtesy of the ANU Archives Program.

For more information on the ANU Archives Program: <http://www.archives.anu.edu.au/>

## Not so hellish

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discovered 20 years ago embedded in ancient sedimentary rock in the Jack Hills, Western Australia, about 350 km north of Perth.

Zircons, typically no larger than the width of a human hair, were extracted from the crushed rock by hand, then scanned using the Sensitive High Resolution Ion Micro Probe to determine their age. Over the past four years, 40,000 zircons have been scanned, yielding only a few hundred over 4 billion years old.

Titanium concentrations in each zircon provided an accurate indicator of the temperature at which the zircons had crystallised. By measuring titanium concentration in these ancient zircons ranging from 4.0 to 4.35 billion years old, the researchers were able to get an accurate measure of the temperatures at which the rocks formed.

"Rocks formed as a result of the thermal energy from meteorite impacts would be bone dry and melt at 900 degrees to 1200 degrees Celsius," Professor Harrison said.

"In contrast, our study has found that Hadean rocks melted at a consistent average temperature of 690 degrees Celsius. Water, which is a very powerful catalyst, must have been present in very large amounts for rocks to melt at such a relatively low temperature."

For there to be sufficient water the researchers say there would have had to have been an atmosphere around Earth, to prevent water from dissipating into Outer Space, and oceans at this time.

"This has profound implications for answering the question: When did the Earth become habitable for life? Virtually all researchers agree that life could not have emerged until there was liquid water at or near the Earth's surface. Thus the Earth may have harboured life for as much as 700 million years longer than currently believed," Professor Harrison said.

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Edited by David Salt

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