SCHOOL OF PHYSICS

ANNUAL REPORT 2003

Contents

Head of School's Report

The year 2003 began on a sad note with the sudden death of Associate Professor Graeme Russell. Graeme had been associated with the School for more than four decades. He served on the staff for over 30 years, and has been one of its most influential members, not only as First Year Director for over two decades but also as a vigorous and engaging colleague. He will be deeply missed. The newly renovated courtyard entrance to the School is to be named "The Graeme Russell Lawn" in his memory.

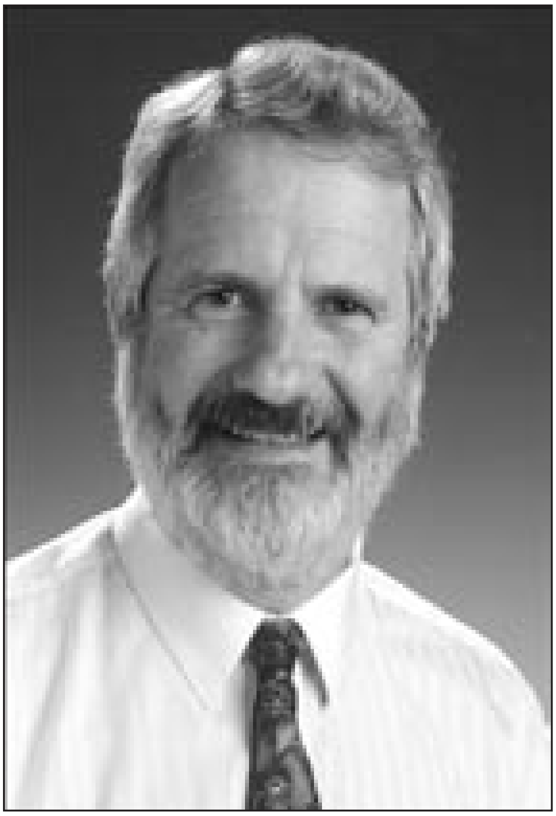
In broad terms the year was one of change and challenge. The new Vice Chancellor, Professor Rory Hume, initiated a process of Vision Planning that engaged the School in a review both of its own priorities and its interaction with the broader community. Three research "focus areas" that will guide the School's future development, were identified: Astrophysics, Biophysics, and Quantum Physics.

The newly appointed Dean of Science, Professor Dennis Lincoln, stepped down after less than 18 months in the position. Leadership of the Faculty then fell to Associate Professor Aldo Bagnara, who successfully navigated us for the remainder of the year.

Professor Jaan Oitmaa, who had served as Head of School from 1993 – 1998, retired mid-year, along with Associate Professor Robert Stening. Both remain closely associated with the School however, and maintain active research programs. We are delighted that the University has bestowed the title of Emeritus Professor upon Jaan, in recognition of his long and distinguished service.

Highlights include the award of an Australian Government Federation Fellowship to Professor Michelle Simmons. Michelle joins Professor Bob Clark as the second member of the School to win one of these prestigious awards, and the School can now boast that it hosts the only two Federation Fellows in the Faculty.

The School's Department of Astrophysics has now been ranked in the top 1% of space science groups world-wide by the international ranking agency ISI. The ranking is based on the total number of citations to published



papers. Interestingly, when the ranking is done on the basis of citations per paper (which takes into account the relatively small size of our group), we actually surpass Caltech, MIT and Oxford.

Teaching innovation continued apace, with particular focus on our laboratories and their role in promoting "active learning". The first stage of our teaching space refurbishment was almost complete by the end of the year, with the entire First Year Laboratory being rebuilt as the "Alpha" laboratory and flexible learning space.

As the year drew to a close, the School was confronting a major financial deficit, brought on by a sudden drop in income as a result of changes to our funding formula at the beginning of 2003. The School's previously sound financial position is now under serious threat, and innovative solutions will be needed in coming years to maintain our position as one of Australia's leading physics schools.

Professor John Storey
Head of School
May 2004

RESEARCH HIGHLIGHTS

Why you can't understand sopranos on high notes

In singing or speech, periodic vibrations of the vocal folds produce a sound rich in harmonics, whose frequency determines the pitch. The vocal tract acts like a variable megaphone, one of whose roles is to match the acoustic impedance between the lower vocal tract (high impedance) and the radiation field (low). It does this most effectively at the resonances of the tract, so the harmonics falling near those resonances are boosted. The frequencies of the resonances depend on the mouth shape and tongue position and we can distinguish vowel sounds and other details of the voice from hearing which harmonics get boosted.

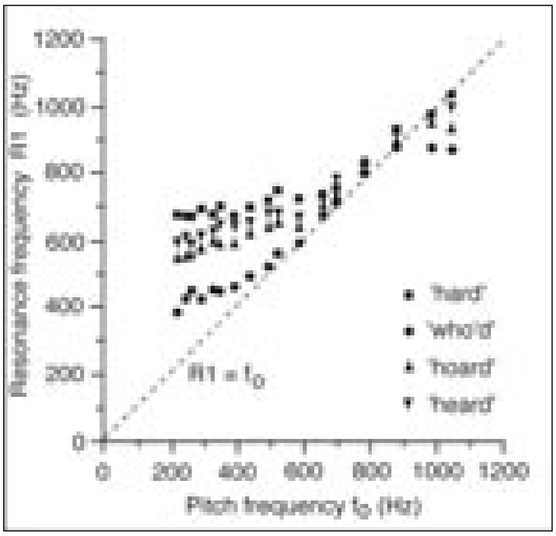
Normally, these processes are independent: we can sing "la la la la la" on different notes (constant resonances with varying pitch), and the monotone Daleks on Dr Who can be understood ("Ex-ter-min-ate": varying resonances at constant pitch). However, there is a problem in the high range of women's voices, because the pitch frequency of the notes enters the range of the lowest vocal tract resonance. If the singers did nothing about this problem, then notes would be louder or softer depending on how well the pitch coincided with a resonance in the tract and the voice quality would be uneven. It has been suspected that sopranos actually tune the resonance of their vocal tract to the note that they are singing: the evidence for this is that they tend to open the mouth wider as they sing successively higher notes. However, this could not previously be confirmed because there was no way to measure the acoustics of the tract while it was being used for singing. The technique developed recently by our Acoustics Laboratory does this by injecting a carefully synthesised broad band acoustic current into the mouth and measuring simultaneously the voice and the response of the tract to this signal.

In the low range of the voice, sopranos do just what we all do in speech and singing: the pitch and the vocal tract resonances are largely independent. In the high range, however, they tune the lowest resonance of the vocal tract to match the pitch they are singing.

This resonance tuning gives them uniform loudness and vocal quality, but it also means that vowel sounds become very similar. However, the amount of intelligibility sacrificed is not great. In the high range, it is very difficult to understand vowel sounds anyway, because of the wide spacing of harmonics. Berlioz' famous treatise on orchestration warns opera composers about the high pitch problem. And it is possibly one of the reasons why the opera house uses surtitles even when the words are in the language of the audience.

Elodie Joliveau, John Smith and Joe Wolfe

Soprano Kristen Butchatsky with the sound source and microphone at her mouth.



The frequency of the first vocal tract resonance, as a function of the pitch frequency, for the four vowels indicated.

Centre for Quantum Computer Technology

In 2004 the Centre for Quantum Computer Technology was expanded to become an ARC Centre of Excellence (COE). The COE involves 18 research programs across 6 Australian Universities, (Universities of NSW, Melbourne, Queensland, Sydney, Griffith, Macquarie), the Australian Defence Force Academy and the Department of Defence.

Research at UNSW is focussed on electronic silicon-based solid state quantum computing in which the quantum bits (qubits) are comprised of single phosphorus atoms embedded in silicon, with quantum information encoded onto the spin or charge state of the atoms.

Constructing these atomic-scale devices is a major challenge, and UNSW houses some of Australia's most advanced capabilities in nanotechnology. Device fabrication is being pursued using two parallel strategies: a "top-down" approach using single ion implantation, and a "bottom-up" approach which uses scanned probe lithography and epitaxial semiconductor growth to achieve atomically precise construction.

During 2003 a number of key milestones were achieved:

• We showed that it is possible to incorporate individual phosphorus dopants into a silicon surface with atomic precision with an STM (scanning tunnelling microscope), a key requirement for making qubit arrays.

• We demonstrated a new technique to construct silicon devices with atomic precision using UNSW's new STM/ MBE system, and used it to construct a fully functional quantum wire in silicon.

• We constructed ion-implanted Si:P double quantum dot devices to demonstrate gate-controlled single electron transfer, a key requirement for all Si-based qubits.

• We demonstrated coincident detection of single electron transfer between buried Si:P quantum dots using two single electron transistors, and used radio-frequency electronics to allow detection on ms timescales.

• We developed high-level logic design for high speed circuitry required to control a quantum processor, facilitating operation of general quantum algorithms.

"Bottom-up" STM fabricated devices

This approach involves using an STM tip to position single P dopant atoms in silicon in an ordered atomic array before they are encapsulated in high quality crystalline silicon grown by MBE. In 2003 we published our work demonstrating the incorporation of single P atoms in silicon with atomic precision.

A second highlight was the construction of a fully functional nanoscale device using the custom-built STM-SEM-MBE system that was installed at UNSW in late 2002. This enabled the development of the first registration process that allows us to locate and make electrical contact to an STM-patterned device once it is outside the vacuum environment.

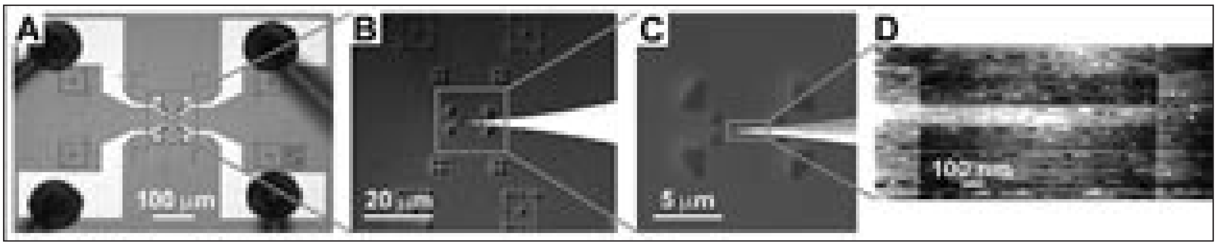


Figure 1. STM fabricated quantum wire. (A) Optical microscope image of the completed device. (B) and (C) SEM images of the STM tip aligned to registration markers. (D) STM image of a nano-wire created by STM.

Figure 1 shows a schematic of a quantum wire constructed with this process. Low temperature magnetoresistance studies of a 4 × 4 μm square and a 90 nm-wide quantum wire showed clear differences between the electrical properties of these two devices, revealing a beautiful demonstration of the cross-over from two-dimensional to one-dimensional electron transport in a quantum wire as the temperature is reduced. These results open the way to creating single atom electronic devices with the STM.

Single electron motion in "top-down" Si:P test devices

In 2003 we constructed and demonstrated a novel double quantum dot structure in silicon using phosphorus ion implantation, a critical test device to assess the potential of Si:P qubits (Figure 2a). Application of a differential bias to the surface gates causes periodic single electron tunneling between the two dots, which is detected with two nearby single electron transistors (SETs) as a discontinuous step in the SET current (Figure 2b). This signal repeats periodically, and using two SETs makes it is possible to detect the charge transfer in coincidence, ensuring that the signal is coming from the vicinity of the double dot system. Single atom devices were fabricated using the Centre's single-ion implantation technology, which uses in-situ ion detector electrodes to produce a signal each time a P^+ ion enters the device.

Quantum measurement: high speed single electron transistors

Measurement of quantum bits will require extremely sensitive electrometers able to detect a fraction of an electron charge on sub-microsecond timescales. We have developed twin radio-frequency single electron transistors and were able to detect single electrons moving between two buried Si:P dots on microsecond timescales (Figure 3). These results show that it is possible to read-out the state of silicon based qubits, and augur well for the future.

Alex Hamilton, Michelle Simmons
and Robert Clark

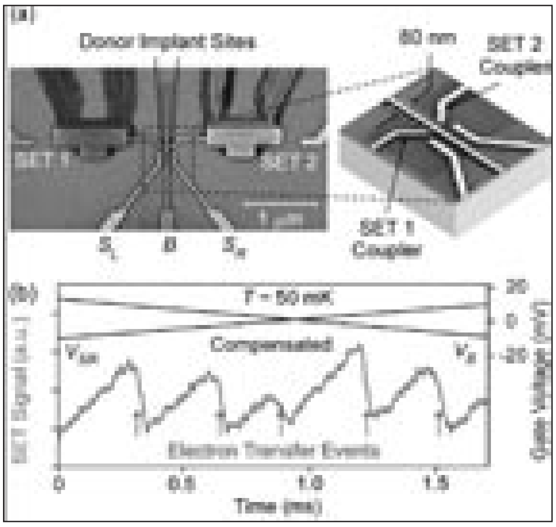


Figure 2. a) Micrograph of ion-implanted twin-SET double quantum dot device with an adjacent AFM image of the central gate area. b) Measurements with an rf-SET of quasi-periodic electron transfer in this device, obtained as a function of time while a differential bias is applied to gates B and S_R.

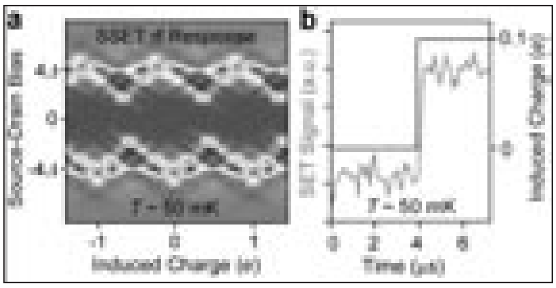


*Figure 3. Characterisation of rf-SETs.
a) Bias spectroscopy of a rf-SET in the superconducting state (B = 0) where Δ is the superconducting gap for Al. b) Single-shot response of the rf-SET to a small step in gate voltage creating an induced charge 0.1e at the SET island.*

Theoretical studies of strongly correlated quantum states in novel condensed matter systems

Discoveries in condensed matter physics during the last 15-20 years have revealed many new phenomena and materials of remarkable richness and diversity. These include the high temperature superconductors with transition temperatures at least five times higher than previously known, "heavy fermion" systems, the "colossal magnetoresistance" (CMR) materials, quantized conductance in quantum wires, the integer and fractional quantum Hall effects, fullerene systems, and the whole field of organic conductors and superconductors.

These phenomena all appear to be manifestations of strong electron correlation effects, and they present a severe challenge to the traditional understanding of condensed matter.

Theoretical models exist, at least in basic form, and must form the foundation of our understanding of these phenomena. The team of Jaan Oitmaa, Chris Hamer, Oleg Sushkov and Robert Bursill was awarded an ARC Discovery grant of approximately $750 000 over the five year period 2003–2007 to determine the properties of these models, in a manner that is systematic and reliable, and to match them with experiment.

In addition to Weihong Zheng, who has been part of our group for many years and is an expert in series expansion methods, we have appointed two recent German PhD graduates, Jesko Sirker and Alexander Weisse, to the team.

During the past year we have progressed on a number of fronts:

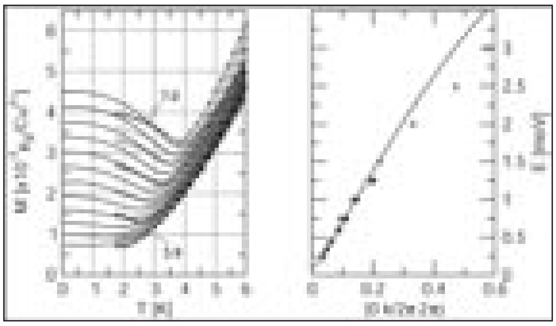
Oleg Sushkov and Valeri Kotov (a former postdoc in our group, and now at the University of Lausanne) have obtained an analytic solution, valid at low doping, for a model of strongly correlated electrons in 2-dimensions, and have demonstrated the coexistence of spiral magnetic ordering and superconductivity.

We have investigated models for several recently discovered new materials, including $Na_xCoO_2 \cdot yH_2O$ which was recently discovered to be superconducting for a range of doping $(1/4<x<1/3)$.

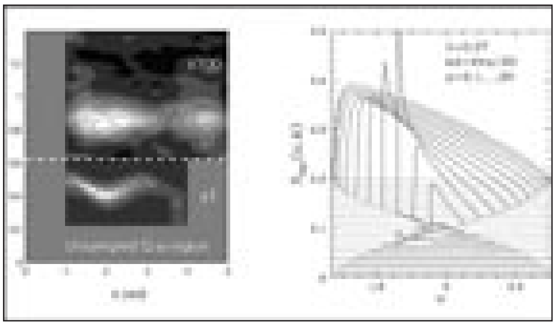
The material $TlCuCl_3$ was discovered a few years ago to have a gap in the magnetic excitation spectrum, but to undergo a transition to a field induced magnetically ordered state. This has been interpreted as a Bose condensation of magnons. We have shown that the proposed simple BEC scenario gives results in disagreement with experiment.

We have also continued to develop numerical methods for calculating energies and spectral weights of multi-particle excitations.

Jaan Oitmaa, Chris Hamer,
Oleg Sushkov and Robert Bursill



Experimental magnetization curves (Nikuni et al., Phys. Rev. Lett. 84, 5868 (2000)) and quasiparticle spectrum (Rűegg. et al., Nature 423, 62 (2003)) compared to our theoretical calculations (solid lines).



Experimental structure factors for $Cu(NO_3)_2 \cdot 2.5D_2O$*, showing both one-magnon and two-magnon contributions, and corresponding model calculations.*

Producing an anti-melanoma vaccine

Principal researchers from the Department of Biophysics, Drs Galina Kaseko and Tohsak Mahaworasilpa, and Professor Hans Coster, are researching methods for producing an anti-melanoma vaccine.

Cancer cells are the body's cells which proliferate uncontrollably and become abnormal. They survive in the body partly because they escape detection by the body's usually very efficient immune system. Melanoma is one of the more aggressive cancers.

Our strategy is to put a suite of "markers" on melanoma cells to enhance the recognition and response of the immune system to these cells. The concept is that, if stimulated properly, our own immune system can then successfully deal with the cancer cells. Indeed in people who have had spontaneous remissions from such cancers, it is known that this is correlated to the presence of antibodies – the "magic bullets"of the immune system – directed against tumour-associated antigens.

We have developed techniques for creating human cell lines that express on their surface the cardinal attributes of a super-set of melanoma antigens. Cell membrane preparations of such engineered cells expressing multiple idiotypic melanoma tumour antigens could be used as a potent and tissue-generic melanoma vaccine. Alternatively, radiation inactivated whole cells from such a cell line could provide the basis of such a vaccine. Our technology has important advantages in that:

• The vaccine so derived will contain a super-set of melanoma antigens.

• The antigens can be produced from the culture of a single cell line.

• The vaccine will be produced in human cells (grown in culture).

Our research has the potential to develop a product with the potential to slash the national and personal cost of melanoma cancers, which is of particular importance in Australia.

Galina Kaseko and Tohsak Mahaworasilpa

In June 2003 the Federal Minister for Science and Technology, the Hon Peter McGauran, visited the melanoma research laboratory in the School of Physics. With him are Dr Galina Kaseko, Dr Tohsak Mahaworasilpa and Prof Hans Coster.

A Multi-Aperture Scintillation Sensor for Antarctica

"How can we measure the turbulence in the Antarctic atmosphere at an altitude of between one and 20 kilometres?" This turns out to be a crucial question when deciding where to build the new generation of Extremely Large Telescopes (ELTs).

A group of us were huddled around a table pondering this question at the 25th General Assembly of the International Astronomical Union meeting held in Sydney during July 2003. The group included colleagues from the Cerro Tololo Inter-American Observatory (CTIO), Caltech, and the Jet Propulsion Laboratory (JPL). We hatched an ambitious plan to build a suitable instrument to make the crucial measurement.

The instrument had to be able to work in an environment where the ambient temperature reaches -75C. It had to locate bright stars and measure them without any human intervention for 10 months. It had to be aligned in bright sunshine during the Antarctic summer. It had to work completely automatically and transmit data back to UNSW using an Iridium satellite phone.

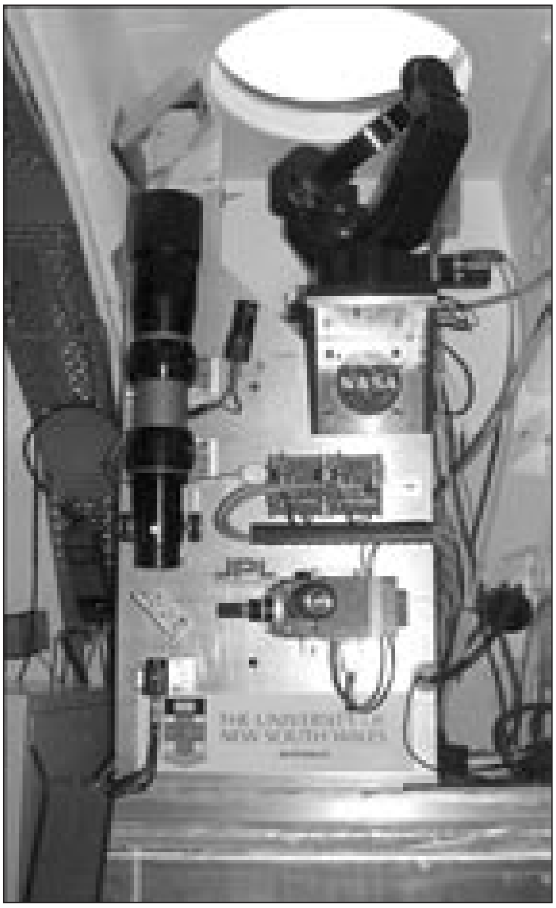
And it had to be designed, built, and shipped to Antarctica before the end of the year.

Our colleagues from CTIO built the detector package, JPL provided some funding, and UNSW designed and built the telescope, CCD acquisition camera, star-tracking mount, and computer control.

The instrument, called MASS (Multi-Aperture Scintillation Sensor), started to come together in November. With two weeks to go before shipping, we desperately needed one or two clear nights to test the instrument on the roof of the Physics building. The clouds cooperated between Christmas and New Year, on the day before we had to ship.

MASS was installed by Jon Lawrence, Tony Travouillon and Colin Bonner at Dome C in Antarctica in January 2004. We are now waiting for the sun to set...(stop press 18 March 2004: MASS has seen its first star!).

Michael Ashley, Jon Lawrence,
Suzanne Kenyon and John Storey



The Multi-Aperture Scintillation Sensor installed in the UNSW AASTINO facility at Dome C, Antarctica.

The Quantum Electronic Devices Group

The field effect transistor plays an important role in modern electronic appliances such as computers and mobile phones. These transistors use a thin, almost two-dimensional sheet of highly mobile electrons or holes to carry electric current. Despite their technological importance many of the fundamental electronic properties of these 2D systems are not yet fully understood.

Our studies of electronic interactions focus on high quality devices fabricated at UNSW featuring two 2D conducting channels separated by an insulating barrier only 2.5nm thick. In these bilayer devices, competition between intralayer and interlayer Coulomb interactions leads to new many-body quantum states similar to those in the fractional quantum Hall effect. In our samples we have the unique ability to tune both the relative strength of these interactions and the balance between the number of electrons in each of the two layers simply by adjusting gate voltages. Our focus in 2003 was the analysis of data obtained from an experiment where we mapped the stability of the bilayer coherent $\nu = 1$ quantum Hall state as electrons were gradually shifted from one layer into the other. PhD student Warrick Clarke spent early 2003 correlating our results with detailed theoretical calculations by Prof Charles Hanna from Boise State University in the US to reach a better understanding of the physics in this system. In late 2003 our focus in this project has shifted to investigating interactions between closely spaced 1D quantum wires, and we are currently fabricating devices for these studies.

The search for a metallic ground state in 2D systems naturally leads to the question of what the precise role of electron-electron interactions is in determining the conductivity. In particular, recent theoretical work suggests that the metallic behaviour observed in these systems may be entirely the result of these interactions, and that a signature of this is consistent behaviour in the quantum mechanical contributions to both the longitudinal and Hall conductivity of 2D systems. To test this hypothesis, Tom Sobey (Session II Honours student) and Carlin Yasin (PhD student) performed a careful experiment to compare these quantum contributions to the longitudinal and Hall conductivity of high-mobility FET devices. They found that these corrections are consistent, thereby confirming an important theory and taking us a step closer to understanding the origin of metallic behaviour in 2D systems.

Warrick Clarke, Tom Sobey, Carlin Yasin, Sean McPhail, Romain Danneau, Adam Micolich, Alex Hamilton and Michelle Simmons

Honours student Tom Sobey performing low-temperature measurements of quantum contributions in high-mobility FET devices.

PhD student Warrick Clarke in the SNF cleanroom fabricating samples for the closely spaced quantum devices project.

Why do bell plates ring?

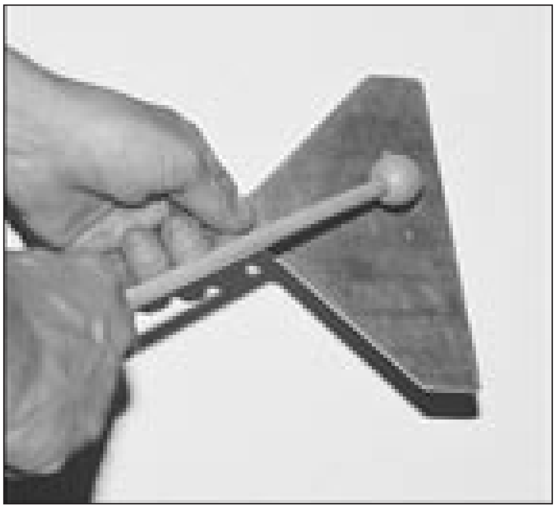
What is surprising when you hit a bell plate is the loudness, clarity and sustain of the sound. Bell plates are polygonal metal plates that are played like handbells but are rather cheaper. However, only a limited class of shapes works for bell plates: in general, polygons with a handle at one corner just go “clunk”. The dependence on shape is critical.

This sensitivity to shape — which is quite astonishing when one holds two slightly different shapes in the hand — is explained by the modes of vibration and the requirements of supporting a percussion instrument. First, the handle must be at a node of vibration: a place where vibrational velocity is zero. Otherwise, translational energy is transmitted to the player’s hand and quickly lost. But this condition is insufficient: local rotation or torques at the handle are also effective at quickly damping the vibration.

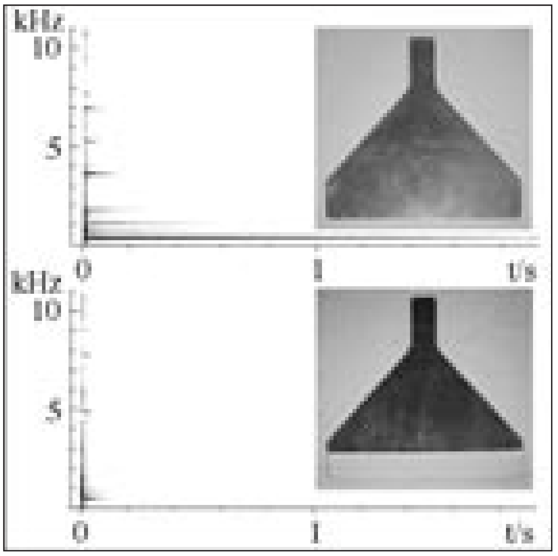
The standard bell plate shape can be considered as a rectangular plate with two corners removed and a tang for the handle attached. The lowest vibrational mode of a rectangular plate has two nearly parallel nodes. Removing successively larger pieces from the corners gradually bends these nodes towards each other. In a family of shapes, which includes that used for commercial bell plates, these nodes fuse at the tang, providing an extended region with neither translational nor rotational motion.

The sonagrams below (amplitude in a logarithmic grey scale vs time and frequency) show the sounds made by striking the plates shown with a rubber mallet. A standard shaped bell plate (top) has several short transients, but its lowest mode rings for much longer than several seconds. After a 25 mm strip was cut from the low edge (bottom), the lowest mode is heavily damped.

Daniel Lavan, John Tann and Joe Wolfe



This shape rings for several seconds. Plates with slightly different geometry are quickly damped.



Sonagrams showing the sounds made by striking the plates shown with a rubber mallet. (Reproduced from our article in Acoustics Australia.)

Ultra Compact Dwarfs: discovery of a new type of galaxy

In its pursuit of understanding objects that are many light-years away, astrophysics inevitably suffers from the “tyranny of distance”. The distances are so vast that from our perspective here on Earth, stars are reduced to point sources of light, galaxies cannot generally be resolved into their individual stars, and planets around other stars can only be detected by indirect means (eg. through the motion they induce or the obscuring effects they have on their parent star).

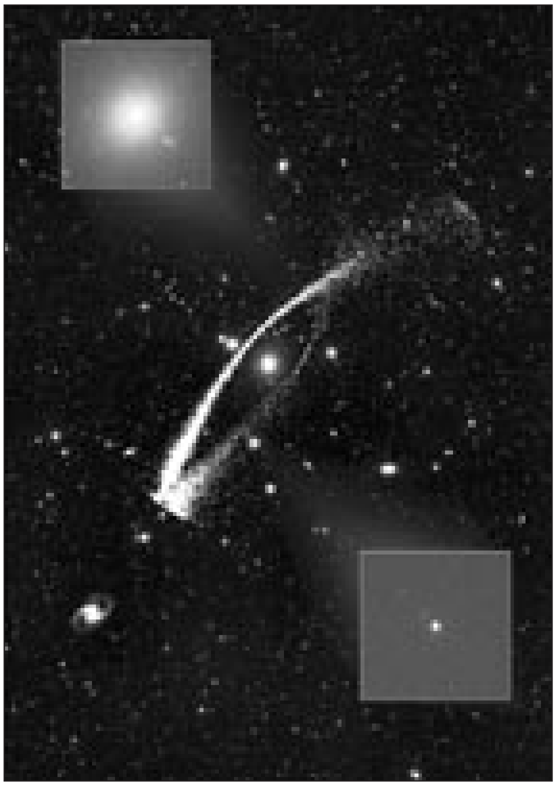
Taken to its extreme, it is conceivable that this problem could cause even galaxies to appear as point sources, particularly those that are rather small and compact. Consequently, such objects would be missed in traditional surveys, where galaxies are identified by their extended and resolved structure. Indeed the notion of a compact, “star-like” galaxy is completely absent from all the morphological schemes used to classify galaxies, for the very reason that none have been found.

The first clues that such a population of galaxies might exist were obtained by Dr Michael Drinkwater (formerly of UNSW, now at Uni of Qld) and his collaborators, when they used the Two Degree Field (2dF) spectrograph on the 3.9m Anglo-Australian Telescope to survey the nearby Fornax cluster of galaxies. This survey was unusual in that it included all objects, be they point-like, extended, or fully resolved spiral and elliptical galaxies. Quite surprisingly, seven of the point-like objects – assumed to be stars in our galaxy – turned out to be members of the Fornax cluster, some 60 million light-years away! The question then was: what were they? Given that they were so faint, were they actually galaxies, or were they just massive star clusters associated with the dominant galaxies in the centre of Fornax?

We demonstrated that these objects are indeed galaxies in their own right, based on further observations made with the Keck and VLT 8-10m telescopes and the Hubble Space Telescope. Remarkably, they are ~10,000 times less luminous than our galaxy and only ~300 light-years across – a type of system previously unknown and which led us to dub them “ultra compact dwarf” (UCD) galaxies.

Through the numerical simulation work of Kenji Bekki, UNSW has made a critical contribution to this study by providing crucial insights into what the origin of these UCDs might be. The most compelling formation mechanism would appear to be one of galaxy “threshing”, where the tidal forces acting within the Fornax cluster strip away the outer envelopes of (the well known) nucleated dwarf galaxies, leaving behind only their naked compact cores. This scenario is captured in the accompanying picture, which shows the Fornax cluster, two of the UCD objects, and a typical orbit (as indicated by the trail of debris) that leads to this destruction.

Warrick Couch and Kenji Bekki



An image of the Fornax cluster in which the new class of ultra compact dwarf galaxies (UCDs) were found. Images of two of the UCDs are shown in the insets. Numerical simulations conducted at UNSW would suggest that they were once bigger galaxies that were stripped down by tidal forces as they orbited within the cluster; the resulting trail of debris predicted by the simulations is superimposed.

How to spot a varying constant

For many years, scientists have endeavoured to find out whether the fundamental constants of physics are really constant, or whether they have changed over the course of time. The search has mainly focused on the fine structure constant, known by the Greek letter alpha (α), which involves the speed of light, as well as the charge of the electron and another parameter from quantum mechanics known as Planck's constant. Back in 1998, Vladimir Dzuba, Victor Flambaum, and John Webb of UNSW suggested a method of searching quasar spectra for varying α that would improve sensitivity by a factor of about one hundred over previous methods. Subsequent measurements provided the first hint that α was different in the distant past.

This unexpected result has inspired much of the work that we do. For example, we are trying to find systematic effects that could invalidate the conclusion that α is varying. The leading contender is that the isotopic abundances in the early universe were different to those on Earth today, which could make it look like α was different even though it was not.

At the same time we are looking for other ways to determine whether α is varying using atomic clocks. Atomic clocks can measure time using different lines in atomic spectra. If we compare two kinds of atomic clocks and see that one is losing time with respect to the other over the course of a few years, we may be able to conclude that α is still changing today. We are calculating how big this drift will be in atoms that are currently of interest to experimentalists. They will use our calculations to choose the most promising atomic clocks, namely those that will stray from each other most strongly. Our group has shown that we can also use atomic clocks to test for variation in the proton magnetic moment, which is another fundamental constant.

Our group has led the way in finding methods that test for changes in other constants of nature, such as quark masses and the constants that control the strong interaction. There are several methods for doing this, all of which involve probing processes that occurred in the early universe. The results that suggest α has varied were obtained by examining the spectra of very distant quasars, and this method can also be used to test whether the proton magnetic moment was different. Then there is the Oklo reactor, which was a natural nuclear reactor in Africa that was working around two billion years ago. Stringent limits can be placed on variation of constants because the reactions taking place back then were the same ones that can happen today. Had the constants been even slightly different, some of the Oklo reactions could not have occurred.

A different method of testing differences in physical constants at the earliest times comes from a theory called Big Bang Nucleosynthesis (BBN), which deals with how the first hydrogen nuclei fused together to create larger nuclei in the first minutes of the universe's existence. Our group realised that the progress of the reactions depends strongly on the constants that control the strong nuclear interaction, as well as on quark masses. By looking at the resulting universe, we can infer their values at the beginning of time.

Julian Berengut

Millimetre observing with the Australia Telescope Compact Array

As far as astronomy is concerned, the radio part of the spectrum encompasses all wavelengths of light greater than about 0.5 mm. Wavelengths greater than 1 cm have long been studied by radio observatories around the world, but the shorter millimetre and sub-millimetre wavelengths have been relatively less explored, partly because of the difficulty of building sensitive receivers in this range and partly because of the obscuring effects of the Earth's atmosphere. However, radiation at these wavelengths carries crucial information about the cold dust and molecular gas from which new stars are born. These wavelengths are also well-suited for observing old stars, solar system bodies, and the leftover radiation from the Big Bang, among other things.

In order to observe astronomical sources in this wavelength range at high angular resolution, a number of millimetre arrays have been constructed around the world, two in the United States (soon to be combined into a single large array in California), one in France, and one in Japan. Meanwhile a Sub-Millimetre Array (SMA) is under construction in Hawaii. However, the southern hemisphere has lacked a millimetre array until now: the CSIRO's Australia Telescope Compact Array (ATCA), previously operating only at wavelengths greater than 3 cm, is being equipped with state-of-the-art 3-mm and 12-mm receiver packages. When this upgrade is complete in mid-2004, the ATCA will be a superb instrument for studying star formation in the Milky Way and its satellite galaxies (the Magellanic Clouds), all of which are best viewed from the southern hemisphere.

In the meantime, a prototype 3-mm system has been available on three antennas of the ATCA since late 2001 and has been extensively used by astronomers at UNSW's School of Physics. Our research programmes include observations of molecular gas in nearby starburst galaxies, searches for biologically important molecules, and studies of regions in our Galaxy where massive star formation is known to be occurring based on surveys of ionised gas and methanol masers conducted at centimetre wavelengths. Because of the limited tuning range and imaging capability of the prototype system, these observations have been used mainly to supplement data taken from single-dish facilities, in particular, the Mopra Telescope and the Swedish-ESO Submillimetre Telescope (SEST). However, once the upgrade is complete, the high angular resolution, superior imaging performance, and exceptional gain stability provided by the ATCA will make it the instrument of choice for a variety of studies. UNSW's depth of experience in millimetre astronomy, a result of its collaboration with CSIRO in the operation of Mopra, will place it in a prime position to exploit the ATCA's new capabilities. Meanwhile, the Mopra Telescope, itself the subject of a major upgrade, will soon be able to efficiently scan the sky to identify sources for high-resolution ATCA follow-up.

Tony Wong

The Australia Telescope Compact Array at Narrabri, NSW.

Dr Tong Wong and A/Prof Michael Burton in the Department of Astrophysics, UNSW.

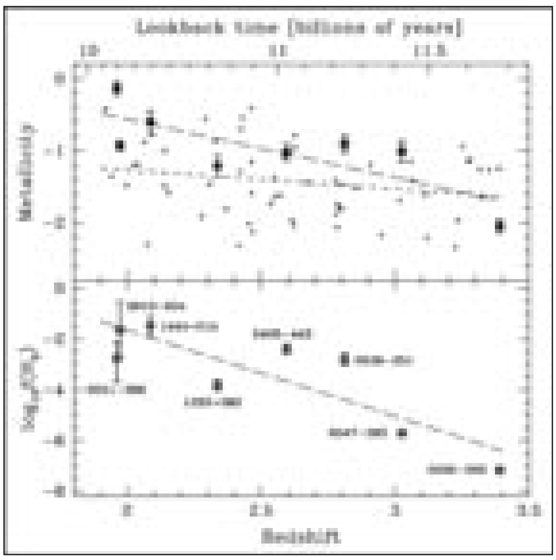
The cosmological evolution of heavy element and molecular abundances

Although the exact nature of Damped Lyman-alpha absorption systems (DLAs) is open to debate, i.e. whether they are the result of galactic disks or small dim galaxies, these dense clouds of gas which intersect the lines-of-sight to distant quasars provide excellent probes of the early Universe. As well as independently testing the big bang model, studies of the primordial and processed gas in these systems can be used to determine the evolution of galaxies and their chemical abundances.

DLAs are identified through their absorption of the Lyman-alpha transition of neutral hydrogen of column densities in excess of $\geq 10^{20}$ atoms cm^{-2}. Although, through metal (elements heavier than helium) absorption features many other atomic species are known to be present, DLAs are very poor in molecular content. This is evident through optical studies of molecular hydrogen and the tracer molecule carbon monoxide. These studies are restricted to redshifts of $z \geq 1.8$ ($\geq 10^9$ light years distant), where the Lyman and Werner H_2 ultra-violet bands, normally blocked by the Earth's atmosphere, are sufficiently redshifted into the optical band. Low molecular fractions have also been confirmed at low redshift by our extensive observations of the rotational transitions of molecular tracers, which are observable with ground-based millimetre wave telescopes.

However, although the molecular abundances are generally much lower than in our own Galaxy, molecular hydrogen has been detected in 8 DLAs (approximately 1/5 of those searched). If we plot this abundance against redshift (see figure) we find a surprisingly tight anti-correlation. A redshift - metallicity correlation is also apparent in which the evolution appears to be steeper and tighter than that of the general population. This suggests that the H_2-bearing DLAs identify a narrower class of object, which could prove very useful in providing a probe, free of the general DLA population biases, of the chemical evolution of the Universe.

Steve Curran and John Webb

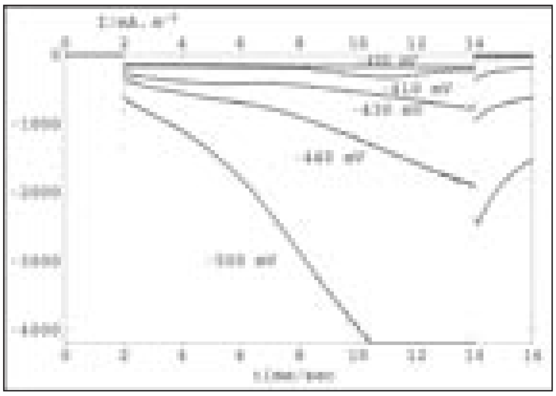


The evolution of metals (top) and molecular hydrogen abundance (bottom) in the early Universe. The filled circles represent the DLAs which exhibit H_2 absorption (least-squares fitted with long dashes) and the small unfilled diamonds represent the general DLA population (short dashes).

New insight into an old experiment

Sebastian Westermann, third year physics student at the Albert-Ludwigs-University in Freiburg, Germany, was about to come to Australia on exchange. He was interested in biophysics courses and wanted to do an experimental project.

I was just reading a paper written by my Glasgow colleague, Mike Blatt, who found Ca^{2+} channels in bean guard cells, which are activated by membrane potentials more negative (hyperpolarized) than the usual cell resting potential difference (PD). In charophytes, Ca^{2+} channels are activated by PDs more positive than the resting PD. The inflow of Ca^{2+} into cytoplasmic compartment opens Ca^{2+}-activated Cl^- channels, initiating the action potential. The outflow of Cl^- was also observed at hyperpolarized PDs by Hans Coster in 1965. Hans modeled the cell membrane as a pn junction and assumed that the large Cl^- currents arise from a punchthrough effect, where the depletion layer grows to one edge of the membrane. In 1986 an Adelaide colleague, Steve Tyerman, argued that the time dependence of the large currents at hyperpolarized PDs points to Cl^- channel-mediated conduction and that these channels are activated by negative membrane PDs. Putting all this information together, I asked the obvious questions: are the Ca^{2+} channels in *Chara* also activated by hyperpolarized PDs and is it the Ca^{2+}-activated Cl^- channel that conducts the currents observed? So, this became Sebastian's project.



The negative currents observed as the Chara membrane is voltage-clamped to hyperpolarized PD levels. The experimental protocol clamps the PD to resting level for 2 sec, to a hyperpolarized level (shown next to each current trace) for 12 sec and back to the pre-clamp resting level.

The cell PD was controlled by voltage clamp. The rise of calcium concentration in the cytoplasmic compartment was estimated by observing the stoppage of cytoplasmic streaming. The Ca^{2+} channels were blocked by application of $LaCl_3$. Sebastian mastered all the experimental techniques and approached the project with maturity of a PhD student. He gathered large amounts of excellent data. Yes, the cytoplasmic streaming stopped, while the cells were clamped to PDs more negative than -350 mV. The negative currents increased with greater Ca^{2+} concentration of the medium. The streaming stoppage was abolished by application of $LaCl_3$, but only some of the negative current. After the negative voltage clamp was released, the cells became more depolarized and the recovery to normal resting PD took many minutes. The amount of depolarization increased as the cell was clamped to increasingly negative PDs. We conclude that the Ca^{2+} channels in *Chara* are opened by hyperpolarization as well as depolarization and the Cl^- outflow in each case is mediated by Ca^{2+}-activated Cl^- channels. However, there is another unexpected effect: the proton pump, which is mainly responsible for the negative resting PD of about -200 mV, is inhibited by the voltage clamps to negative levels.

Mary Beilby

Mary Beilby and exchange student Sebastian Westermann.

Enhancing nuclear fusion

The strongest of nature's four forces is the "strong nuclear force". It makes the Sun shine, providing energy to almost all life on earth. It controls how atomic nuclei interact, creating all atoms via two processes: fission and fusion. Nuclear fission has been harnessed by mankind to generate power on earth for many decades now. But nuclear fusion (where two light nuclei come together to create a larger nucleus) is much more powerful. It is this mechanism which powers the Sun.

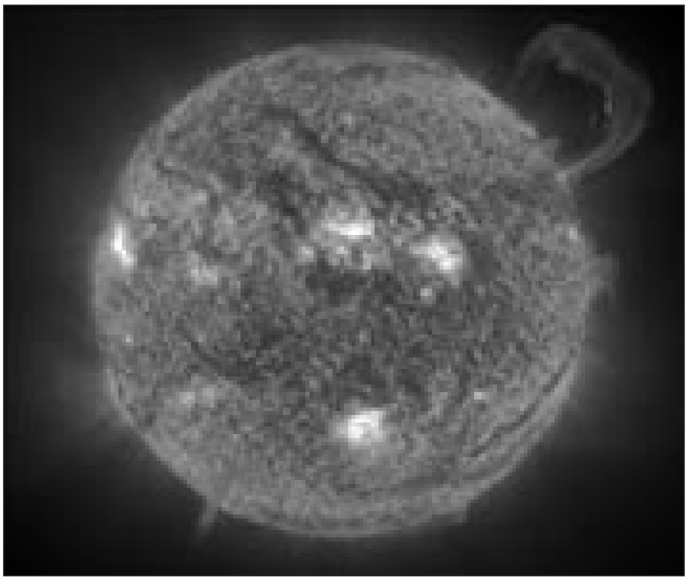
Controlling nuclear fusion on earth has proven to be very difficult. The problem is that atomic nuclei have a very strong positive electric charge that makes them hard to bring together, since like charges repel. To overcome the electric repulsion, the nuclei must be heated to very high temperatures, as they are in stars. These "thermonuclear" fusion devices are very crude, allowing us to make big bombs and little else. But there are other ways to coax the nuclei together. In conventional experiments a beam of nuclei is fired into a target nucleus, sometimes resulting in fusion.

Michael Kuchiev and Victor Flambaum, along with Boris Altshuler of Princeton University have uncovered a new enhancement mechanism that will allow nuclei to come together. Continuing work they started with Vladimir Zelevinsky of Michigan State University, USA, they found that when the target nucleus is surrounded by heavy nuclei, a chain of preliminary collisions transforms the projectile-target experiment into one with colliding beams.

Firstly, a projectile nucleus hits the lighter target nucleus, sending it hurtling away. The projectile nucleus continues along its original path, while the target flies ahead at high speed. The target then bounces off very heavy nuclei in the environment back towards the projectile nucleus, so they are once again on a collision course. Finally they collide inelastically, this time giving rise to a nuclear reaction. This game of atomic ping-pong results in a drastic exponential increase in the probability of overcoming the electric repulsion, and hence sharply increases the likelihood of nuclear reaction.

This seemingly simple idea has many applications in non-equilibrium fusion, such as in understanding how fusion occurs in the explosions of supernovae. It should also help nuclear technology on earth, in fields such as laser-induced fusion, which may one day become an economical means of generating power.

Julian Berengut



Nuclear fusion is the mechanism which powers the Sun.
Photo: SOHO (ESA & NASA)

Organic electronic devices

Plastics are generally considered be poor conductors of electricity. However, the discovery in the 1970s that polymers can be made conductive by manipulating their chemical structure has lead to the exciting possibility of making "electronics on plastic", with associated advantages including mechanical flexibility, robustness, chemical versatility, low weight, and most significantly low cost and ease of large scale production. Already flexible organic display technologies are in the marketplace and significant attention is now being directed towards other organic electronic devices such as transistors and solar cells. Presently much of the electronic properties of these materials are still poorly understood.

In 2003 we continued to expand our new organic electronic devices research program. Early in the year we completed the installation of equipment for the first stage of our new laboratories. This equipment includes a combined RF sputtering and thermal evaporation system, a laminar flow cabinet with spin coater and a deionised water system. In 2004 we will establish a cleanroom and wet chemistry lab for device fabrication.

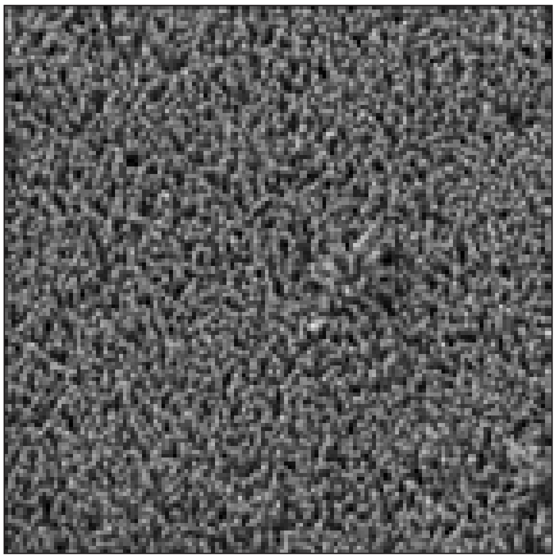
In May, Dr Adam Micolich commenced an ARC Postdoctoral Fellowship to explore the electronic properties of organic field-effect transistors based on molecular crystals and thin-films. As part of this research, Dr Ali Rashid joined our interdisciplinary group in late 2003 to lead the chemistry side of the program, bringing experience in synthesis and the growth of organic molecular crystals. We hope to measure our first samples in 2004.

Our second new project in organic solar cells, with Dr Neil Kemp and A/Prof Richard Newbury, is to explore how polymer/C60 blends can be optimized to increase their photovoltaic efficiency. This project extends on their preliminary work to investigate methods for engineering the morphology of conducting polymers at the nanoscale to improve charge conduction and increase the surface area for exciton dissociation in conducting polymer/C60 fullerene photovoltaic devices.

Finally, an existing collaboration between Dr Adam Micolich, A/Prof Alex Hamilton and Dr Paul Meredith's group at the University of Queensland has continued, with a series of measurements on the electronic properties of ion-implanted plastics. In two series of low-temperature measurements, we began characterizing the crossover between metallic and insulating behaviour as a function of various implant and material properties.

Anthony Tedesco, Neil Kemp, Ali Rashid, Jack Cochrane, Alex Hamilton, Adam Micolich and Richard Newbury

Dr Ali Rashid inspecting a tube containing purified pentacene crystals.



Scanning electron microscope image of a nano-textured surface; each conducting polymer fibril is 50nm in diameter.

Pitch, timbre and register shifting in brass instruments

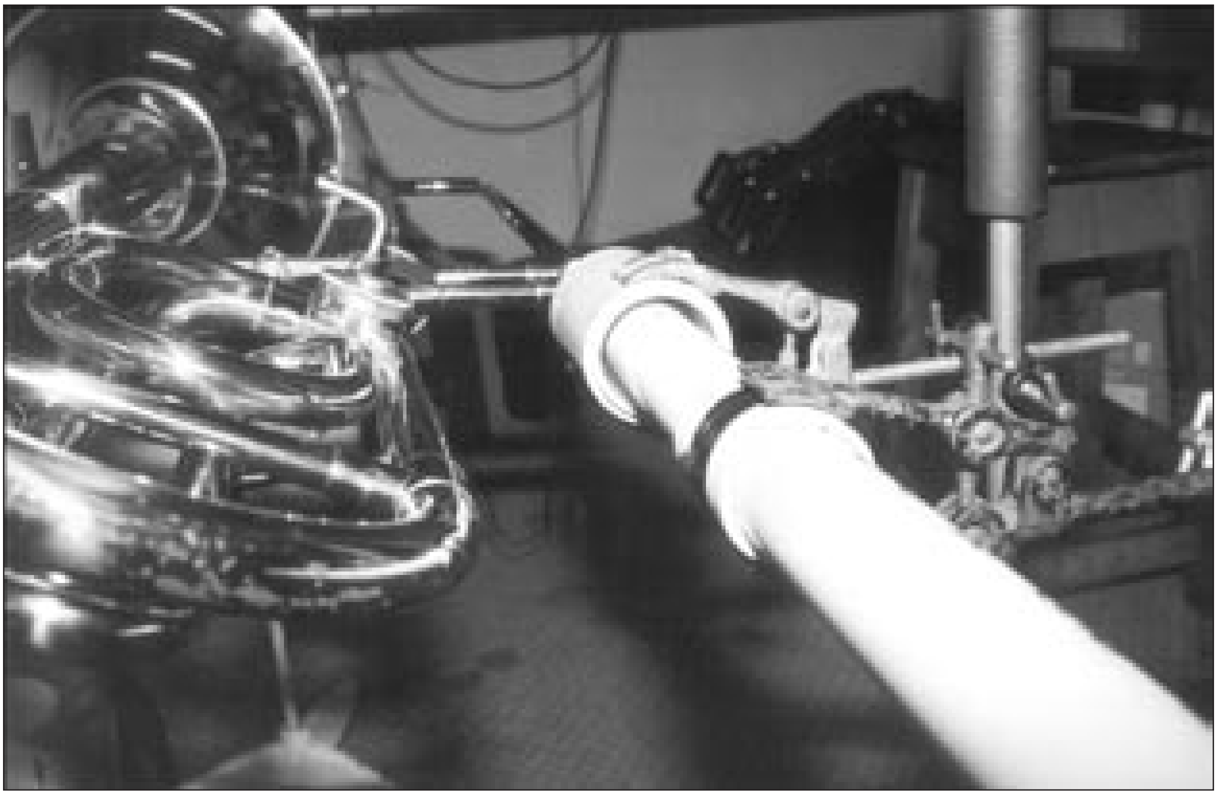
Players of brass instruments know that the position of the tongue is important to the tone and pitch of their instrument, but until recently there has not been a clear explanation. Even unequivocal evidence was hard to come by, because human players tend to control the sound produced by simultaneously varying several variables, including pressure and lip tension.

We provided clear evidence of the influence of the tongue using an artificial trombone playing system. The lips were replaced by a pressure controlled valve, and the player's vocal tract by a series of models that were modelled on the measured cross sections of the human tract with the tongue in different positions.

Changing from the low tongue to high tongue "vocal tracts", we observed small but musically significant pitch changes on notes in the same register, and sometimes also changes in playing register. The timbre was also observed to change: the high tongue configuration produced a brighter sound with stronger high harmonics. These changes are similar to those we measured in a study involving professional trombone players from the Sydney Symphony and from other orchestras.

We explain these changes by comparing the high acoustic impedance of the playing resonances of the trombone and the relatively low impedance of the vocal tract — elements that are effectively in series in the playing configuration. Raising the tongue provides an acoustic "horn" that improves the impedance matching between the two.

Alex Tarnopolsky, John Smith and Joe Wolfe



The artificial trombone playing system.

ROTSE-III: exploring the formation of black holes

On 26 March 2003, after two years of work, the School of Physics completed the commissioning of its ROTSE-III telescope at Siding Spring Observatory. The telescope is designed to study the visible light emitted during the formation of black holes.

Some 2 billion years earlier, a star with a mass about 50 times that of our sun reached the end of its life and imploded, producing a black hole. This event released more energy in one second than the Sun does during its entire 9 billion year life.

On 29 March 2003, gamma-rays from the violent birth of this black hole reached our solar system and were detected by an earth-orbiting satellite. A signal from the satellite was sent to our ROTSE-III telescope, and the telescope automatically moved to the position of the star and took an image. The image showed an explosion one hundred times brighter than any previously observed event. Three days later our ROTSE-III image was on the front page of the Sydney Morning Herald.

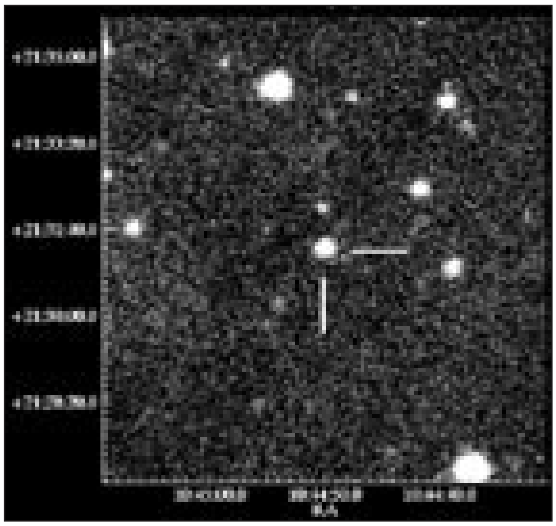
ROTSE-III has since responded to three other gamma-ray alerts, although none as impressive as that of 29 March 2003 — estimated to be a once in a decade event. Of the dozen competing robotic telescope experiments around the world, ROTSE-III's ability to take an image within 10 seconds of the event is unique. This is a crucial time period in which to understand the formation of a black hole and its interaction with the surrounding matter.

We are now eagerly awaiting the launch of the SWIFT satellite in late 2004. SWIFT will provide a rich source of gamma-ray alerts for ROTSE-III.

Our experiment is in collaboration with the University of Michigan, Los Alamos National Laboratories, and Lawrence Livermore National Laboratory.

Michael Ashley and Andre Phillips

The ROTSE-III telescope.



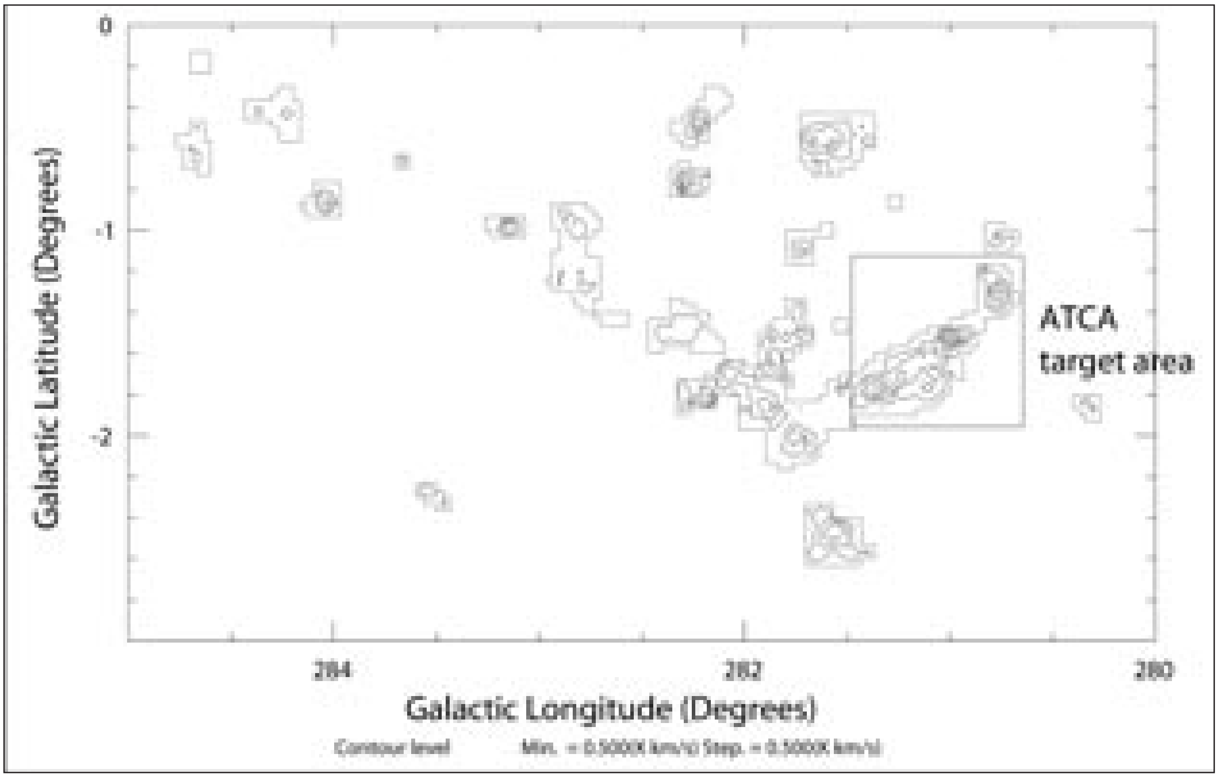
The apocalyptic moment two billion light years away when the giant star exploded.

Medium- and high-mass star formation

In 2003 I have continued my work on star formation. The main project, in collaboration with Phillip Myers of Harvard University is to collect a large dataset on medium-mass protostars, in order to understand their evolution and role in galactic ecology. To this end a number of observing programmes were awarded time on Australian and international telescopes in 2003 (Mopra, the Australia Telescope's Compact Array, and the Swedish-ESO Submillimetre Telescope). These observing programmes were very successful and the analysis of the data is continuing. First results on the demographics of medium-mass protostars will be ready in early 2004.

Another large project, in collaboration with Y. Yonekura and other members of the NANTEN group at Nagoya University, as well as N. McClure-Griffiths (ATNF), is a pilot project for surveying the Milky Way using radiation from interstellar ammonia molecules. This chemical is thought to be one of the best tracers for the cold, dense molecular gas that is the precursor to the formation of new stars in our galaxy. A complete survey of this molecule's emission would yield a wealth of new information on many aspects of high-mass star formation. The pilot project was completed in 2003 and analysis of these data continues as well.

Peter Barnes



NANTEN map of a section of the Milky Way, showing a number of Giant Molecular Clouds in the constellation of Carina. The box shows where we are focussing follow-up efforts using the Australia Telescope Compact Array to make high-resolution maps of ammonia emission from these star-forming clouds.

Black holes are picky eaters

The traditional view of black holes is that of insatiable monsters, devouring everything that strays their way with awesome rapacity. But it turns out that even the largest and most voracious black holes have a modicum of decorum. They filter incoming particles, rejecting those that don't pass their stringent tests.

In the world of black holes, the food is matter: photons – the particles that make up light, as well as other particles such as atoms. Black holes absorb matter because of their event horizon, a "shell" that separates the black hole's interior from the outside world. Once a particle is inside that horizon, it can never come back out. However, a theoretical discovery by Michael Kuchiev, and supported by his calculations with Victor Flambaum, has revealed that black holes actually reflect low energy particles. Only those with higher energy can enter the event horizon.

On the event horizon the gravity of black holes is so strong that quantum physics acts in very strange ways. It splits the vacuum, which then spits out photons, a process known as Hawking radiation. It is a similar quantum magic that leads to reflection from the horizon.

The discovery that the horizon of black holes can reflect particles could have profound consequences for the universe. Just after the Big Bang, matter clumped together to form "primordial" black holes of various sizes. Whether they then grew or disappeared depends on how picky they were about what they ate, and this could lead to changes in the universe today.

Reflection from the horizon is a surprising quantum phenomenon that takes place in the squeezed space-time around black holes. Over two hundred years after black holes were first proposed, and ninety years since they were described using general relativity, these amazing objects are still unraveling their closely guarded, captivating secrets.

Julian Berengut

Some of the theoretical physics staff and students. Back l-r: Julian Berengut, Vladmir Dzuba, Victor Flambaum, Michael Marchenko; front: Elizabeth Angstmann, Michael Kuchiev.

Massive star formation – a PhD student's journey

Because of the nature of massive star formation (i.e., rare, rapid, clustered, and at large distances) the study of these regions – in particular the earliest stages in their evolution, which are not easily distinguished – remains a difficult task.

Much work has been done recently in trying to pin-point the evolutionary sequence of massive stars. It is now thought that they undergo a process of evolution similar to low mass stars, producing distinct indicators of their existence at periodic intervals throughout their evolution. Two of these tracers of massive star formation include the methanol maser and the Ultra Compact HII region (aka UC HII).

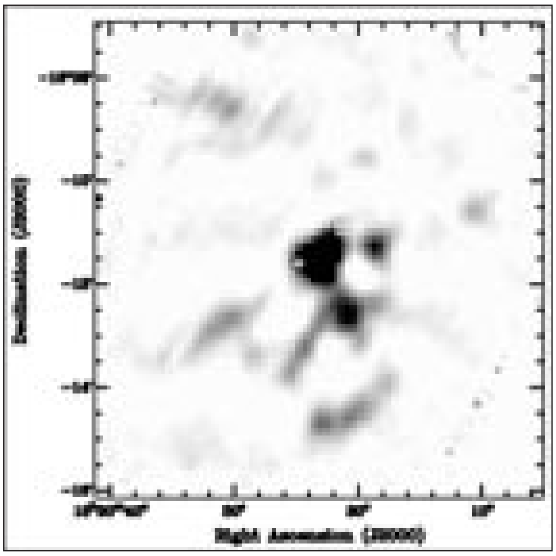
The methanol maser, detectable at 6.7 & 12.2 GHz, is thought to be the first detectable tracer of massive star formation. The radio-bright UC HII region is thought to evolve from the methanol maser. They are produced as the high-mass star increases in mass and luminosity, producing a large number of high-energy UV photons. These photons ionise the surrounding molecular cloud, producing the UC HII region.

By searching for these identifiers of massive star formation it is possible to trace the evolutionary stages of massive stars, provided of course that we know the order in which these tracers appear. This order can be determined by comparing the temperature of these objects, and from this inferring an age.

Complementary to this, we have detected objects in millimetre-wave continuum emission, devoid of these traditional tracers – possibly suggesting a younger age, or that methanol maser emission is directional.

The purpose of my PhD research is to improve our understanding of massive stars, in particular the earliest stages of their evolution. An understanding of massive star formation will allow an insight into the mechanisms involved in the formation of the Galaxy, which is shaped by the presence of these massive stars (e.g. jets, outflows, supernovae winds). Studying these objects may also aid understanding of the first generation of stars formed after the Big Bang, which are thought to have been very massive.

Tracey Hill



The 1.2mm continuum map of a massive star formation region - G15.03-0.67. The map, taken using the SIMBA instrument on the SEST, traces the earliest stages in the formation of massive stars. The "box" in the image represents the position of the UC HII region, and the "plus" symbol the methanol maser.

The Orion Nebula, the closest massive star forming region to Earth (1,500 light years). (photo Jason Ware)

Detection of Tamm surface states in low energy electron scattering from surfaces

Analysis of very low energy electron scattering from atomic structures on solid surfaces gives information about electronic properties such as surface atomic potentials and also the geometric arrangements of surface atoms. Over the last ~30 years, experimental electron reflectivity data for electrons in the kinetic energy range 0 – 50 eV has had features which could not be accounted for. An example is the (111) face on noble, near-noble and transition metals. This energy range in very low energy electron diffraction and microscopy (VLEED/LEEM) and target current spectroscopy (TCS) has been largely neglected.

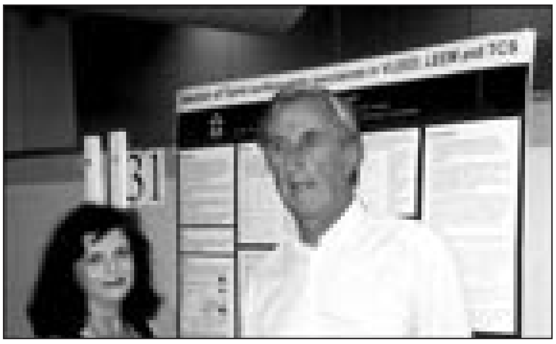
Following a grant from the Gordon Godfrey Fund for Theoretical Physics, Igor Bartos from the Czech Academy of Sciences in Prague visited the School for 3 months for a collaboration with Marlene Read. We found that a hitherto unexplained double peak structure in the reflectivity was due to the splitting of a Bragg peak by a surface state formed from the gradual rise of the constant interstitial potential on approach to the vacuum interface. This type of surface state is localised well inside the solid surface and has historically been called a Tamm state.

Our conclusions are that the formation of this type of surface state has a very significant effect on the reflectivities in the low energy range and should now be incorporated into the theoretical model. It is suggested that failure to model the surface potential realistically in this atomic selvedge region is a major cause of the discrepancies between theory and experiment in the ~30 year history of VLEED.

With this unravelling of the very low energy features we expect to be able to extract details of the energy and momentum variation of many important surface quantities that have not been previously possible to determine.

The formation of surface states on these metals is also important for analysis in other work where alkali metal nanostructures are adsorbed on these surfaces. In this case metallic quantum wells are produced which could be used as electronic devices capable of operation at room temperature. The development of nanoscale electronic devices operating at room temperature is highly desirable.

Marlene Read and Igor Bartos



Marlene Read and Igor Bartos presenting their work on detection of Tamm surface states.

TEACHING HIGHLIGHTS

Teaching quality

In December 2002 the Head of School established a working party (Kate Wilson (chair), Jaan Oitmaa, John Smith, Joe Wolfe) to advise on ways of improving the quality of teaching and learning in the School. The working party produced a report in January 2003 containing 16 recommendations. They emphasized the high priority that the School places on teaching and learning.

The recommendations of the report have been taken very seriously by the School, and are now almost fully implemented. Some highlights are:

• To improve teaching practices, a set of "Guidelines for Lecturers" has been produced by the First Year Director and Undergraduate Teaching Director, containing advice in the areas of course design, assessment practices, learning activities, and student feedback.

• To improve student information, course outlines on the School website have been upgraded to conform with University guidelines, suitable for use as course handouts.

• Improved student feedback mechanisms are being put in place. WebCT pages have been set up for all First Year courses, and higher years will follow. Lecturers have been asked to provide more feedback to students on their progress after assignments and mid-term exams.

• A new special seminar program has been introduced for 2nd year Physics majors, to stimulate their interest in physics, and introduce them to the School's activities. The program includes talks by staff and students, and tours of the School laboratory areas such as quantum computing (Michelle Simmons), photonics (Mike Gal), and acoustics (Joe Wolfe).

• Under the new Postgraduate Assistants scheme, graduate students working as tutors and demonstrators are given training in a series of workshops conducted by both the School and Faculty.

Chris Hamer

First year students working in the new laboratories in the School.

Postgraduate Physoc and seminar series

This year saw the creation of a postgraduate Physoc (the physics students' society) in the School of Physics — which will hopefully increase interactions between the School's postgraduate students. The undergraduate Physoc has been highly successful for many years, with activities including BBQs and social functions playing a key role in assisting budding physicists to find their way, and providing them with a sense of community during their studies. While PhD students have always been a part of Physoc, their role has generally been relatively passive — by creating an active postgraduate Physoc we can increase the school's sense of community and attract more young PhD students to join us.

Towards this goal, in June 2003 a postgraduate branch of Physoc was formed, and a new position on the existing Physoc executive was created (the "Postgraduate Representative") to provide an interface between undergraduate and postgraduate branches. We hope for this fledgling postgrad Physoc to grow strongly in the coming years.

Further, as part of this drive to increase postgraduate student interaction within the school, a postgraduate seminar series was established in the second half of 2003, which was very successful. Thirteen talks were given by PhD students on subjects as varied as black hole cosmology and magnetism in biology.

The seminars, which ran every second week, were beneficial to all of the students. They gave enthusiastic students practice in giving talks, gave everyone the opportunity to see what the other students were doing, and importantly they gave a chance to meet regularly on a social basis, assisted by the attracting power of chips, beer and chocolate biscuits. We look forward to another great series, and continued growth of the postgraduate Physoc in 2004.

Julian Berengut, Jacinda Ginges, Ra Inta, Tony Travouillon and Adam Micolich

Julian Berengut introducing Tony Travouillon's postgraduate seminar.

First year physics student in Antarctica

Colin Bonner, a first year physics student at UNSW, had the opportunity of a lifetime when he was selected to accompany two UNSW astronomers to the remote Dome C station high on the Antarctic plateau.

As part of the Advanced Science program in the School of Physics, students are encouraged to work with research groups. Colin was assigned to a laboratory project in the Department of Astrophysics, where it quickly became obvious that he had very strong skills in electronics. Coincidentally, these were precisely the skills that we needed to help install a suite of new experiments in the UNSW “AASTINO” remote facility at Dome C.

Colin jumped at the opportunity. Over the 2003/4 summer break he assisted us with building instrumentation at UNSW, then accompanied Jon Lawrence and Tony Travouillon on the 5 day ocean voyage to Antarctica.

After crunching through the coastal ice on an ice-breaker, a helicopter ride, and a final trip by light aircraft, Colin became the youngest person ever to visit the Dome C station. During his three-week stay Colin was an invaluable help to our research project, which included installation of the MASS instrument described on page 12.

Michael Ashley

Colin Bonner, Tony Travouillon and Jon Lawrence shortly after arrival at Dome C, Antarctica.

Have refurb, will travel

As third year laboratory director, I recently conducted a tour of senior physics teaching laboratories at ten universities in the UK. The departments visited were chosen for their high ranking in the most recent higher education quality review. The motivation for the tour was to seek out and report on creative teaching techniques and innovative use of teaching space relevant to the context of laboratory teaching, with a view to influencing the planned major renovation of the senior teaching laboratory spaces in our School.

Heads of the visited teaching laboratories were interviewed, photos taken and pertinent local documentation gathered to illustrate relevant findings. Interview questions, suggested by the Innovative Teaching and Educational Technology (ITET) fellows George Hatsidimitris, Iain McAlpine and Kate Wilson, were designed to draw out information relating to recently introduced, as well as forthcoming, initiatives in tertiary physics learning and teaching.

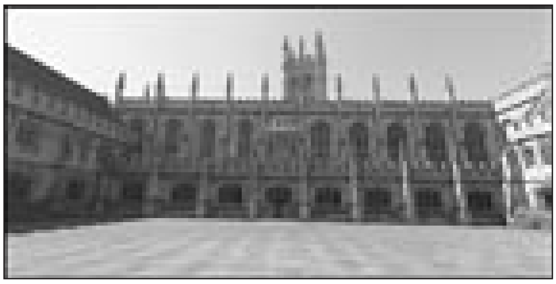
It was found that most of the teaching laboratories dated back, architecturally, to the boom times of the 1960's and 70's and conformed to fairly traditional layouts. The process of refurbishment of these laboratories along much more flexible lines is, however, now commencing as a result of the rethinking of objectives in physics education in the UK. With the relatively recent introduction of four year Master in Science (MSci) degrees in England, major changes have occurred in the structure and delivery of physics programmes; fewer hours are spent by students in the traditional lecture situation while more time is devoted to practical project work and formal training in transferable skills, as desired by prospective employers.

In consultation with our ITET fellows, flexible learning spaces, useful for collaborative student laboratory and project work, student oral and poster presentations and mini-conferences, have been incorporated into our renovation plans. It is apparent that the upcoming refurbishment of our senior teaching laboratories is very necessary and timely in order to keep abreast of developments in tertiary physics education.

Support from George Hatsidimitris, ITET fellow within the School, is gratefully acknowledged.

Barry Perczuk

The tour itinerary.



Dreaming spires at Oxford, one of the universities visited.

Photonics teaching laboratory

Come and visit the new "Photonics" foyer with superb holograms on display!

The demand for the photonics laboratory space has increased with the introduction of the coursework postgraduate programs in photonics developed and implemented by Professor Michael Gal. A major capital works program, managed by Gabriel Caus, has ensured the entire refurbishment of the optoelectronics teaching laboratory: new rooms, new power and lighting, and a new holography work area. The laboratory now enables students to use modern equipment to study and understand the new age of information technology and communications.

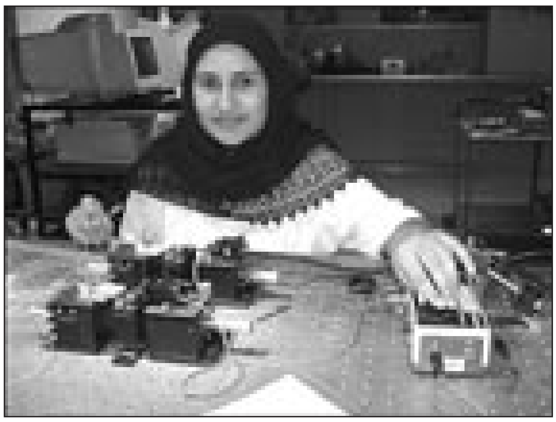
The laboratory can cater for a wider range of students, including: physics majors in their final undergraduate year; photonics engineering students in their third and fourth year; post-graduate coursework students completing the laboratory segment of their programs; and medical and ophthalmology students studying the properties of lasers.

The available experiments cover a wide range of topics:
• Lasers: HeNe gas lasers, solid-state laser diodes and neodymium-YAG lasers.
• Optical fibres: single mode and multimode used as sensors and in communications multiplexing.
• Holography: reflection and transmission holograms are recorded by students.
• Spectroscopy: infra-red/visible using gratings, Fabry-Perot and Fourier transform techniques.

One of the big problems previously was interference from stray light. A major feature of the new laboratory fit-out is the special purpose lighting designed by John Tann. On each of the optical tables in the laboratory, a series of individually dimmable spotlights permits adjustment to just the right level of foreground lighting. This allows students to perform an experiment without causing stray light to interfere with nearby experiments.

The laboratory is also currently host to an expert in holography, Dr Paula Dawson from UNSW's College of Fine Arts. Paula makes large scale holograms, and specializes in the artistic applications of holograms. One of Paula's recent success has been the creation of a large synthetic (computer generated) white-light colour hologram one metre square. A cooperative program between Paula and the teaching laboratory will enable physics students to learn some of the finer points of holography.

Patrick McMillan



Students working in the newly refurbished photonics laboratory.

Would you like some WebCT with that?

Or perhaps some interactive tutorials or a fully online course or two? In recent years a number of enthusiastic teachers within the School of Physics have taken advantage of UNSW programs such as the Innovative Teaching and Educational Technology Fellowship Scheme (ITET) to develop new approaches to learning and teaching, leading to some exciting changes in our courses.

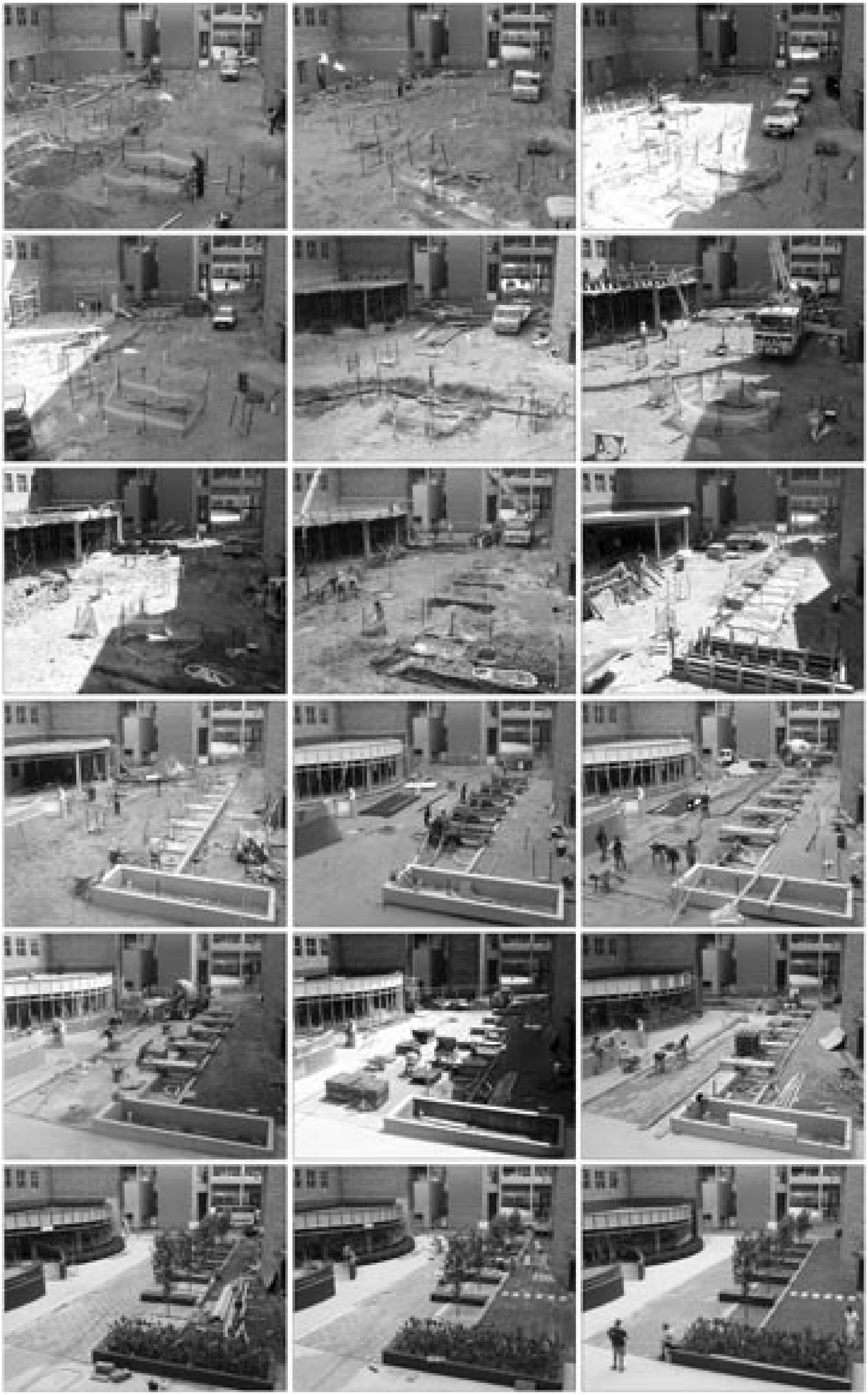
As a result of George Hatsidimitris undertaking an ITET01 fellowship the General Studies courses "Science and Religion" and "Brave New World: Science, Science Fiction and the Future" are now fully on-line, using WebCT to create a virtual classroom to teach some science and get us pondering some of the bigger and weirder questions of life. These courses are popular with both on-campus and distance education students, attracting hundreds of students each year. After this successful start the benefits of the virtual classroom are now extending much further, with all School of Physics courses having a WebCT component.

The most revolutionary changes have been in first year physics and have resulted from a collaboration between ITET fellows George Hatsidimitris and Kate Wilson; First Year Experience Grant recipients Richard Newbury and Kate Wilson; Universitas 21 Fellows Maria Hunt and Kate Wilson; and EDTEC staff Iain McAlpine and Carol Russell. The challenge has been to find innovative ways of making first year more interesting, challenging, relevant, practical and fun. We know this is what students want because as part of the change process we actually asked them! We have met the challenge by providing a more active and relevant learning experience. Workshop tutorials, where students are actively engaged using practical equipment to solve physics problems, have been introduced for some courses. In the laboratory students are now being introduced to an authentic research process, with each student being given the challenge of formulating an experiment of their own. They are encouraged to pick problems that are relevant to either their interests or to their main area of study. One of the great things about supervising these student research projects is learning from the students about the great variety of ways to relate physics in the classroom to the world outside. Studying wave properties by finding out what you need for a really good surfing beach and learning thermodynamics from studying which materials make the best radiator for a high performance car are two recent examples that come to mind.

The revolution continues. Richard Newbury, Joe Wolfe, Maria Hunt, Iain McAlpine and George Hatsidimitris have been awarded a UNSW Capital Grant to introduce multimedia-enhanced interactive and practical tutorials, extending our move to active learning and bringing even more of the world outside into our classrooms.

Maria Hunt

First year aviation students working on their research project for a first year physics course.



SCHOOL HIGHLIGHTS

Soft Condensed Matter and Nanoscale Physics Workshops

Soft condensed matter and nanoscale physics is presently a rapidly growing research field in Australia. As such, it was identified as an ideal focus topic for the 13th Gordon Godfrey Workshop on Recent Advances in Condensed Matter Theory to be held in late 2003. Little did we know at the time that this would grow to become a pair of consecutive workshops spanning four days.

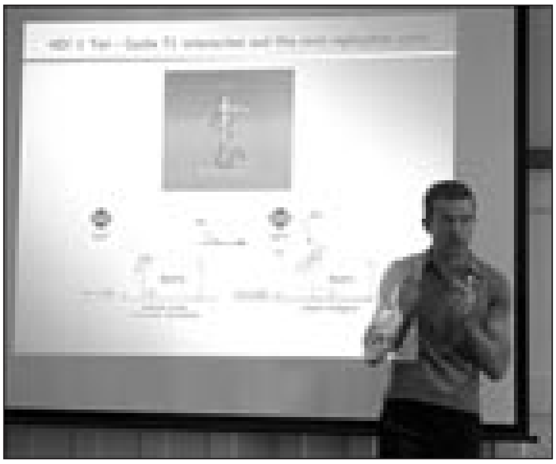
In early 2003, A/Prof Alex Hamilton and Dr Adam Micolich applied for workshop funding from the Missions and Workshops Component of the Innovation Access Programme – International Science and Technology, administered by the Australian Academy of Technological Sciences and Engineering (ASTE) and DEST. Our application was successful and we received $26k to fund a one-off workshop on recent experimental advances in soft condensed matter and nanoscale physics. We were also fortunate in obtaining commercial sponsorship from Agilent Technologies Australia and Oxford Instruments.

From this grew the concept of holding two workshops back-to-back, with the 2.5 day ATSE funded "Frontiers of Science and Technology Workshop on Soft Condensed Matter and Nanoscale Physics" focusing on experimental aspects, flowing seamlessly into the 1.5 day Gordon Godfrey workshop (funded under the Godfrey bequest) which focused on the theoretical aspects of this research area.

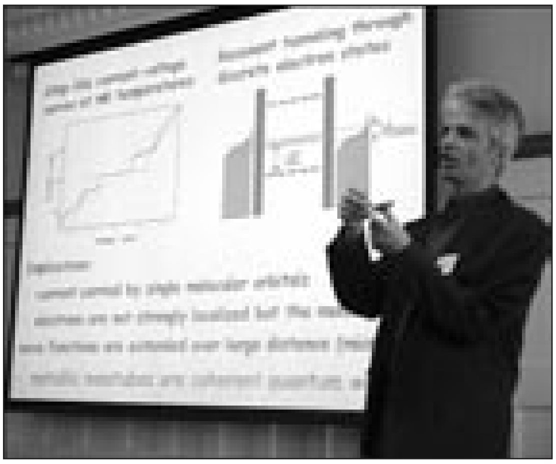
The combined workshops were held on the 1st – 4th December 2003 and had over 70 registered participants. The workshop was opened by A/Prof Aldo Bagnara, Acting Dean of Science, who was followed by the keynote speaker, Prof Cees Dekker from Delft University of Technology in the Netherlands, delivering an excellent talk about his group's work on carbon nanotube electronics, and his recent work in the area of molecular biophysics.

Other international invited speakers included Prof Fabio Beltram, Director of Italy's National Enterprise for Nanoscience and Nanotechnology, who spoke about green fluorescent proteins in biology and bioelectronics; Prof Charles Hanna from Boise State University in the U.S., who spoke about theoretical studies of Bose-Einstein Condensates; and Prof Poul-Erik Lindelof from the Niels Bohr Institute in Copenhagen who spoke about his work on spin effects in carbon nanotubes and the development of single photon sources and detectors. We also had a further 16 Australian invited speakers including three new Federation fellows in the Sydney area (Prof Marcela Bilek and Prof Cathy Stampfl from the University of Sydney and Prof Michelle Simmons from UNSW), and researchers from UNSW and the Universities of Wollongong, Newcastle and Queensland.

Adam Micolich, Alex Hamilton
and David Neilson



Prof Fabio Beltram from NEST and SNS-Pisa in Italy speaking about green fluorescent protein markers in studies of HIV infection of cells.



Keynote Speaker, Prof Cees Dekker from Delft University of Technology, Netherlands talking about the electrical properties of carbon nanotubes.

Mars viewing nights

From the Roman God of War to the home of little green men, Mars has inspired human civilisation for millennia. On the 27th of August, Mars once again caught the public's imagination as it came its closest to Earth in almost 60,000 years. Sydney-siders had a perfect view as, over a couple of weeks, the Red Planet appeared to grow in size to dominate the Eastern evening sky. In response to the intense media coverage and public interest, the astronomy department held a series of Mars viewing nights, open to both members of faculty and the public. The first three talks were quickly booked out and another two evenings were arranged to cope with the demand.

Each night began with an introductory talk outlining the Red Planet's life-story; from the creation of the solar-system to the extraordinarily Earth-like features of the planet we see today such as its atmosphere, clouds, seasonal weather patterns, volcanoes and canyons. The following viewing session at the UNSW Observatory was a great way to get a real close up view through a telescope and some were lucky enough to see the frozen carbon dioxide polar icecaps (but no little green men!) Keep an eye out for the probes that have now landed on Mars, and are searching for signs of past life. We may soon be able to answer the question, "Has life ever existed on Mars...?"

Steven Longmore

Steven Longmore explaining the features of Mars.

UNSW space scientists ranked best on planet

The School's Department of Astrophysics has been ranked in the world's top one per cent of space science institutions by the international ranking agency, ISI Essential Science Indicators.

ESI is a web-based compilation of indicators to assess and rank the global research performance of scientists, journals, universities and nations. Aimed at researchers and policymakers, ESI analyses over ten million journal articles from over 8,500 indexed journals in 22 fields of scientific endeavour.

The Department's top ranking is based on the publication of 372 journal papers that were cited 6,652 times in the past 10 years. ESI updates its rankings bimonthly and publishes them on the website http://in-cites.com/

Over the past 15 years, astrophysics has grown to become one of the three main focus areas of the School of Physics. Supported mainly through external research grants, there are now over 30 people working in this area in various capacities.

The rapid rise in UNSW's citation success in Space Science is the result of several factors, including the development of outstanding new facilities such as the "2dF" instrument on the Anglo Australian Telescope, which has enabled Warrick Couch and his colleagues to make major breakthroughs in the study of the large-scale structure of the Universe.

Australia is very well served with top-class national facilities in both radio and optical/infrared astronomy. In addition, by participating in major international facilities such as the Gemini Observatory, Australian astronomers are able to access the very best telescopes and instruments around the world. UNSW is particularly fortunate in having its own telescopes at Siding Spring, and also operates the Mopra telescope (currently the largest millimetre-wave telescope in the Southern Hemisphere) in cooperation with CSIRO.

Fifty years ago, Australia's reputation in astronomy and astrophysics grew partly out of the competitive advantage of being one of the few technologically advanced nations in the Southern Hemisphere. With other countries now taking advantage of the rich Southern Hemisphere skies, Australia must look at what else it has to offer. Two things come immediately to mind — the vast, radio-quiet areas of sparse population density ideal for construction of future radio telescopes, and the ready access to the exceptional optical/infrared observing sites on the high plateau of Antarctica just a few flying hours from Sydney.

John Storey and Dan Gaffney

Staff and students from UNSW's Department of Astrophysics.

Federation Fellowship for Michelle Simmons

In March 2003, Associate Professor Michelle Simmons, from the School of Physics and Director of the Atomic Fabrication Facility in the ARC Centre for Quantum Computer Technology, was awarded one of 24 Australian Government Federation Fellowships. These are the most prestigious and richest publicly funded research fellowships offered in Australia. They are awarded on the advice of the Australian Research Council to support and encourage Australian researchers to conduct research of significant national economic, environmental and social benefit.

A/Prof Simmons was awarded the Federation Fellowship for her work in quantum electronics, with the ultimate aim of being able to build electronic devices one atom at a time. Her fellowship is the second to be awarded to a staff member from the School of Physics. Professor Bob Clark, the Director of the ARC Centre for Quantum Computer Technology, was one of the initial fellowship recipients in 2001.

Michelle Simmons in the Atomic Fabrication Facility at UNSW.

Awards and prizes

Stephanie Best
Insight Oceania Curie Prize, undergraduate section, Australasian College of Physical Scientists and Engineers in Medicine

Andrew Botros, John Tann, John Smith and Joe Wolfe
Excellence in Acoustics Award, Australian Acoustical Society

Brian Boyle
Science Finalist, The Bulletin's Smart 100

Robert Clark
Science Finalist, The Bulletin's Smart 100
Centenary Medal, Australian Federal Government

Neil Curson
Finalist, British Council Eureka Prize for Inspiring Science

Victor Flambaum
Centenary Medal, Australian Federal Government

Frank Ruess
Best Student Poster Presentation at Condensed Matter Physics Meeting, Wagga Wagga, Australia

Steven Schofield
Best Student Oral Presentation at Condensed Matter Physics Meeting, Wagga Wagga, Australia

Michelle Simmons
Federation Fellowship

Joe Wolfe
Science Writing Award for Professionals in Acoustics, Acoustical Society of America

Astronomy on the Go

In June of 2003, the Astrophysics Department of UNSW in conjunction with the science communication program ran a major outreach activity designed to communicate astronomy to high school students across NSW. The three tours to schools in the North, West and South were designed to coincide with the International Astronomical Union (IAU) meeting held in Darling Harbour in July 2003.

After months of careful preparation by A/Prof Michael Burton, Dr Will Saunders (Anglo Australian Observatory), the staff of the Science Outreach Centre, astrophysics and science communication students, and two German exchange students, the tours kicked off with much enthusiasm. Marton Hidas, Cormac Purcell, Steve Longmore and Tracey Hill, as team leaders, were not only responsible for the chauffeuring of everyone else, but also for coordinating the visits to each school, and ensuring that they went off without a hitch.

The tours to the schools involved giving talks on the Solar System and the Stars to the younger students, and introducing the older HSC level students to Project SEARFE – run in collaboration with the CSIRO in anticipation of a possible Australian location for SKA/ LOFAR. At each stop on the tour, there was also an observing night held for the local amateur astronomers to observe, and satisfy their curiosity about, the heavens. In Port Macquarie, some of the not-so local school children were so keen that they travelled for over 3 hours to attend the observing night.

In all, the Astronomy on the Go tours were a major success. I don't think that any of us involved will forget the thrill of imparting astrophysical knowledge of the heavens to such enthusiastic audiences. Some of us even had the delight of being asked some rather unusual questions (e.g. "are there babies on Mars?" or the little boy who asked one of the presenters if he was single), which added to the jovial nature of the tours.

Tracey Hill

Marton Hidas and Tracey Hill modelling the Astronomy on the Go shirts before heading out on tour.

Michael Burton demonstrating the SEARFE experiment, with four budding science students. Photo courtesy of James Alcock (The Sun-Herald)

Bureaucracy made painless – the Physics approach to OH&S

During 2003 the School of Physics took enormous strides to ensure our OH&S documentation met the appropriate legislative standards. Dr Galina Kaseko is employed by the School to develop its part of a University wide OH&S management system. Galina's approach is to make the bureaucratic process as simple and transparent as possible, thereby helping busy staff and students to document their OH&S compliance in the most efficient way. By the middle of the year, the School, considered one of the more high risk areas within UNSW, was, along with three other areas, selected for a university wide safety audit conducted by WorkCover. Our hard work was recognised when the School, and consequently UNSW, were able to achieve a satisfactory standard in this audit.

Our OH&S committee members are:

- Jack Cochrane, our chairperson
- Jon Everett, the School's safety officer
- Krystyna Wilk, the radiation safety officer
- John Tann, general staff representative and also the laser safety officer
- Pritipal Baweja, workshop representative
- John Storey, Head of School
- Martin Brauhart, representing CQCT
- Galina Kaseko
- Ra Inta, representing postgraduate students
- Justin Dinale, the undergraduate representative

Bob Starrett is now joined by Joji Conducto as a SECO, that empyreal person with the hard hat who ensures safe and timely building evacuations. There are trained First Aid officers in all teaching laboratories and in six other places throughout the School.

So many of us now spend so much time in front of a computer monitor that the OH&S committee enthusiastically endorsed Ra's idea for ensuring that every postgraduate student has an ergonomic chair. This was done by the simple but effective process of buying a bulk order of chairs and providing them free of charge to the students.

As part of the School of Safety Science OH&S auditing course, our School took part in their training exercise for safety auditors. We hope to make this a regular event in the future, as it provides benefits to both sides.

A link to the School Safety Web site is now featured prominently on the front page of the Physics Web. This web page continues to expand and contains School relevant information, forms, documents and links to the UNSW OH&S Management system.

The International Astronomical Union 25th General Assembly

What does a city do once it has held the Olympic Games? Organise the Olympics of astronomy! While it may not be quite so well known as its sporting counterpart, the International Astronomical Union's triennial General Assembly is the biggest thing in world astronomy, and in July 2003 it came to Sydney to spend two glorious weeks in the Convention Centre in Darling Harbour. Two thousand of the world's astronomers came to the event, about a quarter of the professional population in the field on the planet. It fully occupied the minds of many of Australia's own astronomers in the months leading up to the event. Indeed, given the somewhat precarious state of international travel in 2003, for much of the year it looked like the event would flop, but in the end, to the great relief of the organisers, enough people turned up to make it a great success. Following a spectacular opening in the Opera House, and the stunning location in Darling Harbour, the event truly was the "greatest GA ever", to paraphrase a popular quotation from the year 2000.

The School of Physics was heavily involved in the GA. Two members (myself and Jon Everett) were on the National Organising Committee, and the School played a substantive role as well in the scientific program and the outreach program. GA's centre around six scientific symposia, and one of these, IAU Symposium 221 "Star Formation at High Angular Resolution" focussed very much on an area of interest within the School. It fell to our star forming group to run the show, and in particular the three PhD students in the group – Tracey Hill, Steven Longmore and Cormac Purcell – ensured its smooth running. Postdoctoral fellows Vincent Minier and Tony Wong also gave keynote addresses.

The School has a big Antarctic astronomy program, and of course this featured at the GA as well. Following a two day meeting highlighting the successes in the field, a free-ranging discussion of the future big opportunities was held. The latter took place the other side of the Harbour, at Taronga Zoo, another stunning vista which stimulated a remarkable discussion on how to tackle some of the big problems in astronomy by building telescopes at the very end of the Earth.

Finally UNSW played a huge role in running an outreach program, "Astronomy on the Go". As described on page 40, this began well before the GA, involved training 20 students in the skills of science communication, and had a series of practice sessions at schools around the metropolitan district before setting off on three tours to the north, south and west of the State. During the IAU GA itself we ran two Science in the Pub events, including a fascinating debate on "What is a Planet?". We finished off the GA with the School's Day, with 900 school children converging on the Convention Centre to hear four talks on the big questions of life, the universe, and everything — given by Charley Lineweaver, Maria Hunt, John Storey and myself. It was quite a wrap-up to a remarkable week for us all.

Michael Burton

The Convention Centre at Darling Harbour — venue for the IAU's 25th General Assembly.

The Godfrey Bequest — supporting theoretical physics

Gordon Godfrey was a member of the staff of the NSW University of Technology (later renamed the University of New South Wales) when it was founded in 1949. In 1951 he was appointed Associate Professor of Applied Physics, and remained a member of the staff of the School of Physics until his retirement in 1958. He was the first representative of theoretical physics at the University. Subsequent to his retirement he held an appointment for a time as Honorary Visiting Professor at UNSW, and until his death that of Honorary Associate of the School of Physics.

Professor Godfrey taught, first in secondary schools and then in tertiary institutions, throughout his entire career. His research in theoretical physics encompassed several areas. His MA thesis, written in 1919, was probably the first paper written in Australia on special relativity. He also published work on atmospheric radio propagation and on the reflectance characteristics of multilayer coatings.

Following the deaths of Professor Godfrey in 1979, and his wife Mrs Mabel Godfrey in 1980, the Godfrey Bequest was established. This gift funds a number of initiatives supporting theoretical physics at UNSW.

The Godfrey Bequest primarily promotes the advancement of theoretical physics within the University by providing financial support to assist in the travel and accommodation expenses of academic visitors to the University in this area. Seven researchers visited UNSW during 2003: Professor Mark Whittle (USA), Dr William Barford (UK), Dr M. Troyer (Switzerland), Professor Mihkail Kozlov (Russia), Professor Vladimir Dmitriev (Russia), Professor John Barrow (UK) and Professor Igor Bartos (Czech Academy of Science).

Another area of support is the undergraduate prize recognising outstanding performance in third year theoretical physics, which was awarded to Anthony Tedesco in 2003. There are also Gordon Godfrey scholarships awarded to outstanding students pursuing postgraduate study in theoretical physics. Two students received these scholarships in 2003: Julian Berengut and Alex Von Brasch.

In 2003 the 13th Gordon Godfrey Workshop was held. This year's workshop was focussed on the theoretical aspects of soft condensed matter and nanoscale physics and was combined with the ATSE funded "Frontiers of Science and Technology Workshop on Soft Condensed Matter and Nanoscale Physics", which looked at experimental aspects of this area.

Obituary
Professor Graeme John Russell

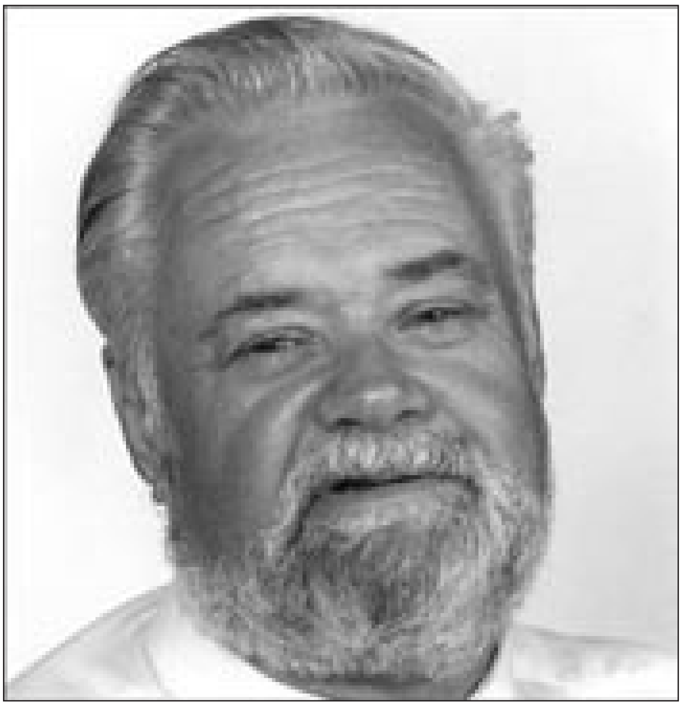
Graeme was one of the first students in the newly introduced Science degree course at UNSW. He graduated with First Class honours in Physics in 1962 and then enrolled as a PhD student in the School. His thesis was in experimental surface physics, investigating thermally induced defects on semiconductor surfaces. In those days experimentalists built much of their equipment and the skills Graeme acquired in vacuum systems and the like were to stand him in good stead in his later work.

Graeme joined the staff of the School of Physics after obtaining his PhD. During a career extending over more than three decades he made outstanding contributions to all three areas by which academics are judged: research, teaching, and service to the institution and the discipline. His research continued in surface physics and semiconductors until the mid 1980's when, together with Professor Ken Taylor, he formed a new Advanced Electronic Materials research group, which built very much on his knowledge and experimental skills. He was co-author of some 170 papers in the international research literature, as well as a comparable number of conference papers.

He was a dedicated teacher and served as Director of First Year Studies in the School for over twenty years. He not only ensured that the large First Year teaching program ran smoothly but took particular pleasure in lecturing the first section of the syllabus to incoming students. At the other end of the spectrum he was a diligent and caring supervisor of some 20 PhD students, including many international students.

His service to the School and to the University was equally outstanding. Most notably he was Chair of the Board of Studies of Science and Mathematics for some ten years, and was a member of the Academic Board of the University for the same period, including chairing the Board's Undergraduate Studies Committee. On top of this he also played a significant role in the secondary Higher School Certificate syllabus and examination committees, chairing the latter committee for some years.

After his retirement Graeme continued his work as a visiting professor in the School until his death in January 2003. In recognition of his contributions the newly redeveloped courtyard entrance to the School will be named "The Graeme Russell Lawn".



Staff of the School of Physics

Professors

Robert Clark
Experimental investigation of quantum physics in low dimensional semiconductors and semiconductor nanostructures and their application to the next generation of electronics and computing.

Hans Coster
Electrical properties of living cells and the membranes surrounding cells; impedance spectroscopy and the electro-dynamics of cells in radio frequency electric fields leading to the creation of hybrid cells which have the potential to produce therapeutic materials such as monoclonal antibodies; related research includes electrodisinfection of water, biosensors and molecular films.

Warrick Couch
Optical astronomy, observational cosmology, galaxy evolution and formation particularly in rich clusters; large-scale structure and galaxy redshift surveys; supernovae, distant searches, rates in nearby galaxies.

Victor Flambaum
Theoretical Physics; atomic, nuclear, elementary particle, solid state, astrophysics, quantum chaos and statistical theory.

Michael Gal
Experimental Condensed Matter Physics: the study of the optical properties of semiconductors, semiconductor layer structures and interfaces; optoelectronics; optical instrumentation (particularly modulation spectroscopy and ultra-fast laser spectroscopy).

David Neilson
Condensed Matter Theory: strongly correlated electron systems in semiconductors; metal-insulator transition in 2D; disordered electron glass; electron bi-layers; quantum wires; superconductor-nanostructure interfaces.

Jaan Oitmaa
Solid State Theory: phase transitions and critical phenomena; magnetism; lattice dynamics; superconductivity.

John Storey
Infrared, far-infrared, mm and radio astronomy, HII regions, molecular clouds and star formation; infrared detectors and instrumentation; electronics, imaging, antarctic astronomy.

Oleg Sushkov
Quantum many body theory including condensed matter, nuclear and atomic physics.

Associate Professors

Michael Ashley
Astronomical instrumentation; astronomy in Antarctica; optical transients from gamma ray bursts; extra-solar planets; wide-field photometric surveys.

Michael Box
Radiative transfer in the earth's atmosphere; multiple scattering, perturbation techniques; climate effects of aerosols, remote sensing from satellites; scattering by haze and cloud particles.

Professor Jaan Oitmaa (now Emeritus Professor), who retired from the School of Physics in July, 2003.

Michael Burton
Infrared astronomy, including the interstellar medium, supernova remnants, shock and fluorescent excitation of molecular clouds, star formation and the galactic center; millimeter astronomy; Antarctic astronomy; science communication.

Seán Cadogan
Magnetism and hyperfine interactions in metallic compounds; amorphous metallic alloys; Mossbauer spectroscopy, neutron scattering, muon spin relaxation.

Paul Curmi
Structure and dynamics of biological macromolecules; x-ray crystallographic studies of protein structure; molecular dynamics simulations; protein folding and stability, understanding the function of enzymes at atomic level.

Chris Hamer
Lattice gauge theory of the strong interactions; critical phenomena in statistical mechanics.

Alex Hamilton
Quantum transport phenomena in low dimensional semiconductor structures (2D quantum wells, 1D quantum wires, and 0D quantum boxes), and the effects of inter-device interactions in multi-component semiconductor nanostructures; solid state quantum computation.

Gary Morriss
Equilibrium and nonequilibrium statistical mechanics, chaotic dynamical systems, molecular hydrodynamics.

Richard Newbury
Experimental condensed matter: low dimensional semiconductor systems, mesoscopic devices; studies involving very low temperature, high magnetic field; high pressure physics; superfluidity and superconductivity.

Michelle Simmons
Experimental condensed matter physics: nanofabrication and cryogenic measurement of quantum electronic devices; understanding how ultra-pure, low dimensional systems conduct electricity; atomic-scale fabrication of a solid-state silicon-based nuclear spin quantum computer using scanning tunneling microscopy (STM) and molecular beam epitaxy (MBE).

Robert Stening
Electric currents and fields in the ionosphere, winds and tides in the upper atmosphere which drive these currents; lunar tidal effects on the ionosphere; computer models of the low-latitude ionosphere.

John Webb
Cosmology, Hubble Space Telescope observations; quasar spectroscopy; light element abundances; variability in the Fundamental Constants.

Joe Wolfe
Music Acoustics: investigations of musical instruments, of the human vocal tract and of their interaction; information, coding and processing of sound in the ear and in artificial systems; thermal physics in biology, especially cryobiology and water relations.

Senior Lecturers

Mary Beilby
Molecular basis of salt tolerance in plants. Unusual transport systems in marine algae bryopsidophyceae; multimedia in research and teaching.

Marlene Read
Surface state band structure, electron and positron scattering from solid surfaces, surface structure analysis; electrodynamics; relativistic mechanics ("special relativity"); geometrodynamics ("general relativity"); physics education.

John Smith
Electrical characteristics of biological and artificial membranes; electrodiffusion theory; acoustics of musical instruments and the vocal tract; optimization of impedance measurements.

Lecturers

Gail Box
Inversion of multispectral radiometer data to obtain information about aerosol size distribution; aerosols and the visual air quality of Sydney; relationship between physical and chemical properties of aerosols and their optical properties.

Peter Eyland
Spherical cap harmonic analysis.

Maria Hunt
Molecular line astronomy; millimetre wave astronomy; observational interstellar chemistry; biomolecules in the interstellar medium; chemistry of star formation regions.

Krystyna Wilk
Isolation, characterization and structure determination of algal light harvesting proteins; research involves crystallization of proteins and analysis of x-ray diffraction data obtained for protein crystals.

Kathryn Wilson-Goossens
Physics education.

Emeritus Professors

Heinrich Hora
Laser and plasma theory (quantum and relativistic effects) multivalley band theory for semiconductors.

H. Julian Goldsmid
Thermoelectric materials and devices.

Adjunct Professors

Barry Allen
Biomedical physics, particularly in the area of experimental radiation oncology and in vivo body composition.

Brian Boyle
Cosomology, the large scale structure of the Universe and the properties of quasars.

Neville Fletcher
Music acoustics.

Robert Robinson
Strongly correlated f-electron systems, magnetism in uranium intermetallics, the dynamics of amorphous materials and neutron-scattering instrumentation.

Adjunct Associate Professors

Michael James
Molecular films and neutron and x-ray scattering instrumentation.

Anatoly Rosenfeld
Research and development of silicon semiconductor radiation detectors for spectrometry and dosimetry of nuclear radiation with application in high energy physics and radiation oncology and diagnostic. Study of change collection in silicon detectors and their radiation damage; theoretical and experimental macro-micro dosimetry in mixed radiation fields on different radiation oncology modalities.

Adjunct Senior Lecturers

Peter Barnes
Star formation in molecular clouds, phases of the interstellar medium, galactic structure, small bodies in the solar system, observing techniques.

Associate Professor Robert Stening retired from the School in July 2003. He is pictured with the Head of School, John Storey.

Nigel Freeman
Medical physics.

Richard Smart
Development and validation of internal dosimetry techniques with specific application to modalities.

Research Staff

Kenji Bekki
Astrophysics; numerical simulations of galaxy processes.

Christopher Blake
Astrophysics; large-scale structure studies using distant radio galaxies; cosmology.

Louise Brown
Biophysics.

Tilo Buehler
Development of fabrication and measurement technology towards quantum limited detectors of relevance for quantum computing.

Robert Bursill
The theory of excited states in conjugated molecules, computational quantum chemistry, low-dimensional systems in condensed matter, lattice gauge theory.

Stephen Curran
Astrophysics — observational cosmology.

Neil Curson
Fabrication of nanoscale devices and studies into gas/surface reactions, using scanning tunneling microscopy.

Andrew Ferguson
Application of low temperature measurement of silicon nanostructures to the quantum measurement program.

Hsi Sheng Goan
The strength of hyperfine and exchange interactions of P donors in Si. Characterise sources of noise and decoherence in SETs.

Frederick Green
Theory of non-equilibrium transport and noise in nanostructures and devices.

Andrew Greentree
Application of coherent quantum optics to coherent electronics devices for quantum computation. Investigation of the coherent/incoherent interface.

Steven Harrop
Structure and architecture of proteins by x-ray crystallography.

Neil Kemp
Mesoscopic Devices.

William King
Protein Structure.

Michael Kuchiev
Multiphoton many-electron processes in atoms in strong laser fields; atomic collisions which result in final states with several low-energy charged particles; physics of instantons and its application to quantum gravity.

Jon Lawrence
Astrophysics.

Charles Lineweaver
Cosmology: temperature fluctuations in the cosmic microwave background; cosmological constant; combining constraints from the cosmic microwave background with constraints from other cosmological data; exobiology.

Linda Macks
Fabrication and measurement of quantum structures in the development of quantum computer devices via the “top-down” process.

John Markham
Solid State Theory.

Sean McPhail
Condensed matter physics; electrical and optical measurement of semiconductor quantum devices at milli-kelvin temperatures.

Adam Micolich
Experimental studies of the electron properties of strongly interacting semiconductor nanostructures; fabrication and measurement of organic electronics and nanodevices.

Vincent Minier
Astrophysics.

Lars Oberbeck
Fabrication of atomic-scale devices in silicon using scanning tunneling microscopy (STM) and molecular beam epitaxy (MBE) towards silicon quantum computing.

Louise Ord
Astrophysics.

Andre Phillips
Airborne remote sensing; infrared instrumentation and satellite communications.

Igor Polonsky
Atmospheric physics; radiative transfer.

David Reilly
Physics of quantum-measurement of cryogenic (mK) temperatures, focusing on radio-frequency single electro-transistors and spin interactions in quantum wires.

Virginia Shepherd
Plant cell biology; fluorescence microscopy, cytoskelton, cell-to-cell communication, dynamic vacuoles, action potentials, the ascent of sap, Australian native fish (especially gudgeons) ostracods, life of temporary ponds, history and philosophy of science; life and work of JC Bose.

Jesko Sirker
Solid State Theory.

Fay Stanley
Nanofabrication and infrastructure development for the Integrated Quantum Computer Devices program.

Marion Stevens-Kalceff
Condensed matter physics, microcharacterisation of the defect structure of wideband gap materials, irradiation induced defect generation and transformation, advanced electron microscope techniques and scanning probe microscopy.

Boaquin Sun
Optoelectronics.

Tooru Taniguchi
Theoretical Physics.

Alexandre Tarnopolsky
Music Acosutics.

Panayiotis Tzanavaris
Astrophysics.

Wilfred Walsh
Astrophysics.

Alexander Weisse
Solid State Theory.

Matthew Whiting
Astrophysics.

Tony Wong
Astrophysics.

Ernestas Zasinas
Theoretical physics.

Wan Hua Zheng
Optoelectronics.

Wei Hong Zheng
Lattice gauge theory, statistical physics and condensed matter theory; linked cluster expansion techniques; phase transition and critical point phenomena.

Visiting Professors

John Barrow
Astrophysics.

Igor Bartos
Theoretical physics.

Wallace Geldart
Solid state theory.

Poul Erik Lindelof
Nanostructures.

Benno Schoenborn
Biophysics – neutron diffraction and impedance studies of important biomolecules.

Alan Walker
Mechanisms of solute transport in plant cells; models for mycorrhizal infection and root growth in plants and of combined nitrogen movement through ecosystems.

Martin Zuckermann
Theoritical investigations of (i) the phase behaviour and physical properties of lipid bilayer membranes including lipid-sterol and lipid-protein interactions, membrane rupture (lysis) and the structure of lipid systems related to the stratum corneum of mammalian skin, (ii) polymer problems including the properties the properties of polymer brushes and an examination of heteropolymer collapse with a view to understanding protein folding, (iii) kinetics of wetting for ternary systems containing surfactants, (iv) magnetism of weakly frustrated ferromagnets and (v) pattern formation of mammalian visual cortex.

Visiting Fellows

Arthur Anderson
Use of ultrasonic techniques to study oxygen related structural changes and processes in high temperature superconductors and the relationship of these phenomena to superconductivity.

William Banford
Solid state theory.

Vladimir Dmitriev
Atomic and nuclear theory.

Michael Drinkwater
Hidden galaxies in the local universe; leader of the Fornax Spectroscopic Survey in collaboration with A/Prof. Warrick Couch (UNSW) and A/Prof. Rachel Webster (Melbourne).

Anthony Duff
Protein structure.

David Hambly
Protein structure.

Madan Kaila
High temperature superconductor materials and devices; materials/devices for optical/ infrared radiation detection; mathematical/ computational modelling to design optimum performance detectors for use at 77K.

Galina Kaseko
Antibody response of human lymphocytes upon antigenic stimulation in vitro (in vitro immunization of human lymphocytes).

Mikhail Kozlov
Atomic and nuclear theory.

Ned Ladd
Astrophysics.

Tohsak Mahaworasilpa
Effects of electric fields on biological cells; Electro-mechanics of biological cells; Electrical cell fusion for the production of human hybridomas; human Monoclonal Antibody Production from hybridomas.

Nasser Shahtahmasebi
Theoretical physics – solid state.

Christopher Young
Photometric surveys of galaxies.

Research Assistants

Melinda Taylor
Astrophysics

Administrative Staff

Ranji Balalla
First Year Office

Joji Conducto
Administration & Finance

Patricia Furst
Administration & Teaching

Susan Hagon
Teaching

Gavin Hicks
CQCT

Karen Jury
CQCT

Venus Lim
CQCT

Stephen Lo
Administration & Finance

Galina Kaseko
Administration

Kim Puckey
CQCT

Savita Sardana
CQCT

Alisha Toft
CQCT

Robert Walton
CQCT

Professional Officers

Nathan Boddam-Whetham
CQCT

Gabriel Caus
First Year Computing Laboratory

Terry Chilcott
Biophysics

Jack Cochrane
Magnetic Materials & Mesoscopic

Vladimir Dzuba
Theoretical

Jon Everett
Astrophysics

David Jonas
Computing

Patrick McMillan
Third Year Laboratory

Barry Perczuk
Third Year Laboratory

Bob Starrett
Semi-Conductors

John Tann
Optoelectronics & Musical Acoustics

Frank Wright
SNF

Technical Consultant UNIX

Kristien Clayton
Computing

Cryogenics Manager

David Barber
CQCT

Senior Technical Officers

Michael Benton
Second Year Laboratory

George Hatsidimitris
Webmaster

Garry Keenan
Demonstration Unit

Ping Lau
Electronic Workshop

Andre Skougarvesky
CMP & SNF

Technical Officers

Anthony Frith
First Year Laboratory

Mark Lu
Electronic Workshop

Technical Assistants

Diana Edler
First Year Laboratory

Susan Fraser
First Year Laboratory

Acting Foreman

Ken Jackson
Mechanical Workshop

Laboratory Craftsman

Pritipal Baweja
Mechanical Workshop

Store Officer

Dave Ryan
Administration

Casual Research Assistants

Andrew Botros
Musical Acoustics

David Bowman
Musical Acoustics

Timothy Byrnes
Theoretical Physics

Jane Cavanagh
Musical Acoustics

Merlinde Kay
Atmospheric Physics

Mushtaq Loan
Solid State Theory

Yi Qin
Atmospheric Physics

Frank Reuss
Quantum Electronic Devices

Tamara Reztsova
Atmospheric Physics

Casual Technical Officer

Dror Ben-Naim
Optoelectronics

Steven Longmore
Astrophysics

Casual Technical Assistant

Paul Dickens
Demonstration Unit

Ra Inta
Demonstration Unit

Tamara Reztsova
Demonstration Unit

Casual Laboratory Supervisor

Jack Sandall
Student Staff Workshop

Casual Professional Officer

Rolf Brenner
CQCT

Michelle Rudd
CQCT

Postgraduate students

Marc Ahrens
Supervisors: A/Prof A. Hamilton; Dr A. Greentree
Investigations of Coherent Effects in Qubits Using High-Frequency and Fast Pulse Electronics

Christopher Angstmann
Supervisors: A/Prof G. Morriss; A/Prof P. Curmi
Dynamical Systems, Application to the Lorentz Gas

Elizabeth Angstmann
Supervisor: Prof V. Flambaum
Variation of Fundamental Constants

Julian Berengut
Supervisor: Prof V. Flambuam
Many-body Theory and Violation of Fundamental Symmetries

Alan Blood
Supervisors: Prof H. Coster; Dr T. Chilcott
Biological Effects of Alternating Electric Fields

Till Boecking
Supervisor: Prof H. Coster
Molecular Mechanisms of Polyene Antibiotics

Zahra Bouya
Supervisors: Dr G. Box; A/Prof M. Box
Atmospheric Aerosols and Effects in Sydney

Rolf Brenner
Supervisors: Prof R. Clark; A/Prof A. Hamilton
Measurement of Al/Al_2O_3 Single Electron Transistor Devices

Tilo Buehler
Supervisors: Prof R. Clark; Dr A. Dzurack
Semiconductor Nanotechnology

Tim Byrnes
Supervisors: A/Prof C. Hamer; Dr R. Bursill
DMRG in Lattice Models

Paolo Calisse
Supervisor: Prof J. Storey
Antarctic Site Testing for Astronomy

Warrick Clarke
Supervisors: A/Prof A. Hamilton; A/Prof M. Simmons
Experimental Condensed Matter Physics

Nadia Court
Supervisors: Prof R. Clark; Dr D. Reilly
Readout and Control for a Silicon Quantum Computer

Neil Crighton
Supervisor: A/Prof J. Webb
Observational and Theoretical Cosmology

Steven Crothers
Supervisors: A/Prof J. Webb; A/Prof M. Ashley
Extra-solar Planets: Optimal Photometry Methods

Tamara Davis
Supervisors: A/Prof J. Webb; Dr C. Lineweaver
Theoretical Cosmology: Recession Velocities Greater Than the Speed of Light

Jessica Dempsey
Supervisor: Prof J. Storey
Antarctic Astrophysics

Paul Dickens
Supervisors: A/Prof J. Wolfe; Dr J. Smith
Flute Acoustics

Jacinda Ginges
Supervisor: Prof V. Flambaum
Calculation of Parity Non-conservation in Heavy Atoms

PhD student Nadia Court with Professor John Storey.

Kuan Goh
Supervisors: A/Prof M. Simmons; Dr L. Oberbeck
Encapsulation and Electrical Isolation of Phosphorous Qubits in Silicon

Michael Green
Supervisor: A/Prof J. Wolfe
Acoustics of Organ Pipes, Especially Scaling and Related Phenomena

Daniel Grether
Supervisors: Dr C. Lineweaver; A/Prof M. Ashley
Celestial Mechanics, Exoplanets, Statistical Analysis

Taleb Hallal
Supervisor: Dr G. Box
Atmospheric Physics

Toby Hallam
Supervisors: A/Prof M. Simmons; Dr L. Oberbeck
Hydrogen Lithography as a Tool to Realising Atomic Scale Devices

Marton Hidas
Supervisor: A/Prof J. Webb
Observational Astrophysics

Tracey Hill
Supervisors: A/Prof M. Burton; Dr M. Hunt
Massive Star Formation

PhD student Julian Berengut explaining his research to fellow students at the School's postgraduate poster day.

Tammy Humphrey
Supervisors: A/Prof R. Newbury; Dr H. Linke
Quantum Ratchets in Semiconductor Nanostructures

Suhrawardi Ilyas
Supervisor: Prof M. Gal
Optical Spectroscopy

Ra Inta
Supervisors: A/Prof J. Wolfe; Dr J. Smith
Guitar Acoustics

Oleh Klochan
Supervisor: A/Prof R. Newbury
Transport in Low Dimensional Semiconductors

Maja Kuzmanoski
Supervisor: A/Prof M. Box
Atmospheric Radiation

Dene Littler
Supervisors: Dr S. Breit; A/Prof P. Curmi
Structure of CLIC Proteins

Steven Longmore
Supervisors: A/Prof M. Burton; Prof J. Storey
Star Formation

Mykhaylo Marchenko
Supervisor: Prof V. Flambaum
Many Body Theory

Dane McCamey
Supervisor: A/Prof A. Hamilton
Quantum Computing: Studies of Silicon Interfaces, Charge States and Spin Properties

Erin McKay
Supervisor: Dr R. Smart
Radiation Dosimetry Techniques

Gabriel Mititelu
Supervisor: A/Prof J. Webb
Astrophysics

Timur Mukhamedjan
Supervisor: Prof O. Sushkov
Strongly Correlated Electrons

Johan Noor
Supervisors: Prof H. Coster; Dr T. Chilcott
Membrane Biophysics/ Low Frequency EIT

Masoumeh Pashaeinejad
Supervisor: Prof B. Allen
Targeted Alpha Therapy

Michael Pracy
Supervisor: Prof W. Couch
Evolutionary Studies in Clusters of Galaxies

Cormac Purcell
Supervisor: A/Prof M. Burton
Massive Star Formation

Peter Reece
Supervisor: Prof M. Gal
Optical Spectroscopy of Semiconductors

Frank Ruess
Supervisor: A/Prof M. Simmons; Dr N. Curson
Towards the Realisation of a Silicon Based Quantum Computer

Steven Schofield
Supervisors: Prof R. Clark; A/Prof M. Simmons
Atomic Manipulation of Silicon Surfaces Using STM

Clare Sloggett
Supervisor: Prof O. Sushkov
Lattice Gauge Theory

Humara Sultana
Supervisor: Prof M. Gal
Liquid Hydrogen Storage

Paul ten Boom
Supervisor: A/Prof J. Webb
Cosmology

Hiroyuki Toyozumi
Supervisor: A/Prof M. Ashley
Computational Astronomy

Tony Travouillon
Supervisor: A/Prof M. Burton
Antarctic Astronomy

Alexander Von Brasch
Supervisor: Prof J. Oitmaa
Condensed Matter Theory

Rena Widita
Supervisors: Dr L. Holloway; Prof H. Coster
Radiotherapy Planning

Matthew Williams
Supervisor: Dr P. Hoban
Intensity Modulated Radiotherapy

Carlin Yasin
Supervisors: A/Prof M. Simmons; A/Prof A. Hamilton
Experimental Condensed Matter Physics

Clifford Yee
Supervisors: Dr Y. Li; A/Prof M. Ashley
Mathematical Techniques for the Creation of Image Using Ultrasound

Postgraduate Director Prof Mike Gal (centre) with PhD students Ra Inta and Peter Reece at a seminar on Ra's research into guitar acoustics.