

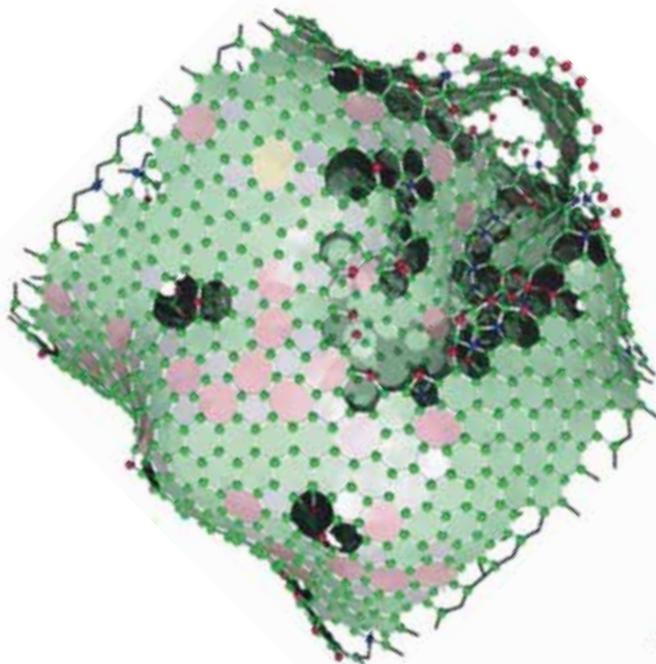
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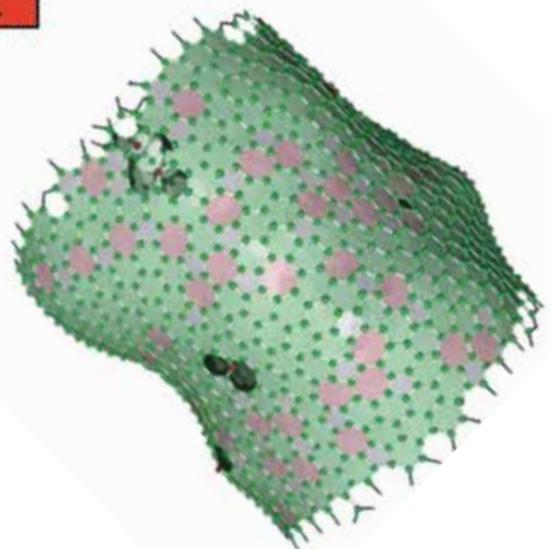
A Publication of the Australian Institute of Physics

*Promoting the role of
physics in research,
education, industry
and the community*



Molecular Dynamics

Computer simulation as a "third way"
for physics



Australia and the Large Hadron Collider

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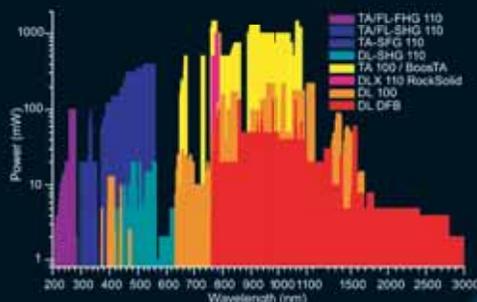
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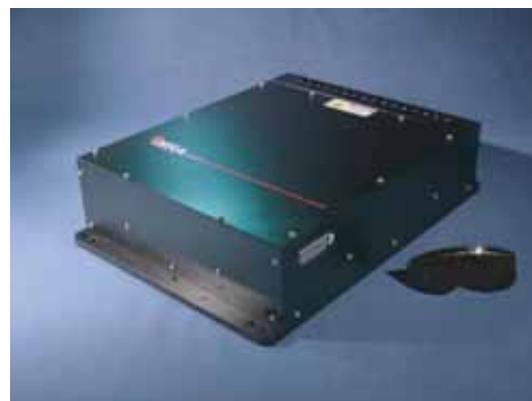
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Cover Image:

The image shows sp²-bonded carbon arranged into multi-wall nanotubes as modeled using Molecular Dynamics. To read more see the full article by Nigel Marks beginning on page 160.

Image credit: Nigel Marks

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Submission Guidelines

All articles for submission to Australian Physics should be sent in electronic format. Word or rich text format are preferred. Images should not be embedded in the document, but should be sent as high resolution separate attachments in eps, tiff or jpg.

Authors should also send a short bio of themselves and a recent photo.

The Editor reserves the right to edit articles based on length, space requirements and editorial content.

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President's Column



School Education: Will we every get it right?

Public Education has been identified¹ as the main component to developing a resilient society; providing preparedness for the future, a means for mobility to higher socio-economic standards, and greater national prosperity resulting in reduced dependence on social security.

In recent weeks, the Australian Government has been focusing on their "Education Revolution"² to turn around education. Their major action to achieve this is the public reporting of school performance. However, there is broad ranging evidence on the impact of reporting on school performance with some experts saying there is a positive effect while others find no improvements³. Many studies show that it is not uncommon for schools³, when required to report outcomes, to artificially boost their results using a range of different techniques (cream skimming, increased time spent on test preparation, exclusion of poorly performing students, and outright cheating).

This is a "borrowed" idea from the USA, a consequence of Minister Gillard's visit there. The philosophy is that "good" schools will attract more students while "poorly performing" schools will loose them forcing schools to merge or close. Is this really going to revolutionize education in Australia?

Why is the Australian government looking to the USA for direction when their education quality is not benchmarked compared to other OECD countries? Although the monitoring of a school's performance may be a part of improving equality in education, a better metric is to measure the value added by a school. In the 2007 study of quality and equity of OECD countries, Australia, USA and UK were all clustered as high quality and low equity while Finland, Korea and Japan were clustered as high quality and high equity. Ms Gillard would do well to visit Finland to see what they do.

Finland is hailed as having one of the most successful education systems in the world. What drives this high level of achievement? How does a small affluent country such as Finland maintain a high wage, high skill economy? As Finland cannot compete with the low-cost economies of Asia, it must, as a matter of economic survival, invest heavily in education and training. Finland has, in a short time, transformed its economy from a timber felling, agricultural economy to a high tech economy associated with the mobile phone company Nokia and education has been identified as its "fast forward" button⁴.

Finland has 5.3 million people on a large landmass where education is considered an end in itself. This differs significantly from the American and Australian view of education as a means to an end, a stepping stone to better paying jobs and to impress others. This distinction may explain our obsession with private schools, and how we structure, operate and fund all schools.

Australia spends about \$8k per secondary student per year⁵ on school education with a complex structure of private and public schools with single sex, co-ed, speciality and selective schools. The Finns spend US\$5k a year per student, operate no gifted programs, have an average class size close to 30 and do not begin schooling children until they are 7 years old. Finland has a multicultural mix with 23.3 % of students classified as immigrants.

Finnish teachers are revered and teenagers place this profession at the top of their list of favoured professions. They are not paid more than their counter parts in other European countries; however, they have high job satisfaction due to great freedom in their instructional practices as long as they adhere to the core national curriculum. The Finns do not administer national standardized testing, but use sample testing with individual school results being confidential. Schools are not ranked or compared. Data collection is only for the school and the National Board of Education, and is used to improve instruction. Naming and shaming is unthinkable. Fundamentally the business model of education used unsuccessful by the USA and soon to be adopted by Australia is at odds with the education model used by a country with the world's finest schools.

Another difference identified as contributing to their effectiveness is that the Finns love reading; so much so that the government provides a reading book pack for every newborn child as a "baby bonus". They use subtitles instead of dubbing of popular TV shows. Teachers use chalkboards and overhead projectors instead of electronic white boards and PowerPoint presentations. Finland has roughly equal funding per student across the country. The gap between the best and poorest performing schools is very small.

So what options does Australia have? The government says it has limits on the budget for education. That being the case, we need to aim for a greater equity of resources provided by schools. We need to reduce the support that leads to the over servicing of some private schools. Over the period from 2002 to 2005, private school capital investment increased from \$1380 per student to \$1560 per student while public schools' annual capital investment barely moved from \$540 per student. In many schools within the private education sector, this capital funding is being used to over service the provision of infrastructure with minimal impact in the "quality" of the education.⁶

There is excellent efficiency of investment in public schools in Australia. Australian schools perform consistently above their funding weight (OECD data shows Australia is 15th out of 30 countries in per capita expenditure for schooling while it ranks 4th in terms of mean literacy and numeracy outcomes for primary and secondary students.⁷) Imagine how good all schools could be if the inefficiencies that arise from Commonwealth allocations to already well resourced and high performing non-government schools were more equitably distributed?

continued on page 153

AIP Web site: www.aip.org.au

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Editorial



No doubt much of your time over the last few weeks has been spent participating in ad hoc discussions concerning the science and purpose behind the Large Hadron Collider. This free publicity has provided us with a great opportunity to bring the joy and thrill of "big physics" to the fore. We should not squander this occasion.

With the firing up of the OPAL Reactor, our 2008 National Congress approaching, the International Year for Astronomy in 2009 at our doorstep and musings of a national science curriculum (like it or not), we need to command that all of our available resources (human and financial) be directed to a prime goal: one way or another science, and in particular physics, remains prominently in the mind's eye of the public, and of politicians, for yet another year.

That appeal is easier said than done, but as Stephen Pincock notes in Australia and the Large Hadron Collider (see page 164): "*At last count, the project has involved more than eight thousand physicists from universities and laboratories in 85 countries... It has been more than twenty years in the making.*" The international collaboration required to bring about the design, construction, operation and financing of the Large Hadron Collider is certainly one for the scientific record books, only the Human Genome Project comes to mind as an equivalent effort.

There is one flaw in this ointment; the only item that might stand in the way of capitalizing on this publicity in the long run: education.

Cathy Foley notes in the President's Column that the education recommendations from the 1993 report *Physics: A Vision for the Future* sound as if they were written this year. "*Very little has changed. The same issues are still being raised and it appears that any initiatives undertaken do not seem to make any impact,*" she writes. Which suggests one of three things: either we have failed to act on the recommendations; or our actions have failed to alleviate the problems noted; or trying to alleviate the problems noted is insurmountable.

Accepting that educational reform is insurmountable would not only be defeatist in nature, it would be incorrect given the evidence from other nations, Finland being a prime example as Cathy Foley alludes. What appears most likely is that we have either failed to act, or that our actions have failed.

It is clear that collaboration on educational reform is no simple request given its highly politicised nature. No doubt countless decisions are yet to be made by a myriad of well-intentioned players as this drama plays out. But decisions are only the beginning, action is key for success and action requires policy, procedure, procurement and follow-through. All of which must be measurable.

A national curriculum is no promise of success, but our ability to focus and collaborate on one outcome, namely education, certainly will be a means to our success. There is much to learn from the success behind the collaboration for the Large Hadron Collider.

It brings to mind a riddle: Three frogs are sitting on a log. Two decide to jump off. How many frogs are left on the log? Answer: three. Two had only decided to jump off, they never acted on that decision.

John Daicopoulos

Write an article for Australian Physics

We are looking for articles covering all aspects of physics in Australia. Perhaps your area of Physics is not well known, is unusual in some way, or you work at a smaller university; perhaps your career has developed in unconventional ways; if so, why not write an article for Australian Physics? For more information contact editor-in-chief A/Prof Brian James (B.James@physics.usyd.edu.au).

President's column – continued from page 151

Finland has a different culture and history to Australia. It would be easy to suggest that we adopt their style of schooling, but such an approach could never be achieved and probably not be as effective in the Australian context. Can we develop some innovative ways to make our current complex system work better? Can we increase the attractiveness of teaching as a career? One important way is to increase teacher's salaries; although it is unlikely that a government would be able to afford an immediate 50% salary increase. So is it possible to find savings via productivity gains? Can we double teacher salaries by shifting the way we structure the educational programs and their development? For example, can we reduce the overhead cost of teachers being off class for curriculum planning and development by undertaking this activity in the school holiday period. Teachers and schools adopting this approach could get increased funding or the teachers could be paid higher salaries for their participation.

The National Board of Employment, Education and Training report (1993) *Physics: A Vision for the Future*⁸ contained many exciting recommendations including building a new nuclear reactor and a synchrotron. Many other scientific research recommendations and proposals have been achieved in the following 15 years. However, when you read the section on school education you would think it was only written last week. Very little has changed. The same issues are still being raised and it appears that any initiatives undertaken do not seem to make any impact.

So if we are going to see stronger and better education in Australia, including public and science education, we need to act. Some ideas to consider are:

- Adopt a bipartisan philosophy that the equity of education for every child be paramount.
- Explore ways for simplifying the complex mechanisms that have developed in providing school choice. There is no study that shows this provides better education.
- Work with teacher unions to develop a paradigm shift on the labour force structure of teaching to enable productivity gains as the impetus for increased teacher salaries.
- Provide truly equal funding per student.
- Engage parents to be more involved with their children's education. There are mixed participation rates with some parents very involved with others having no involvement at all. Can schools become community centres that attract parents reaping the benefits for themselves and their children from such involvement?

No doubt these will be seen as naïve suggestions; however, if we are going to get education right in Australia, we need to dig deep and make significant structural, cultural and labour force changes. Is Australia up to it?

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Letters

Dear Sir:

I read with interest the President's Column in July / August Edition of Australian Physics on the Commercialisation of Physics Research.

Since graduating in the early 1980's I have been involved in industrial physics and commercialisation of products and processes. It surprised me to read the list of lessons learned about how to commercialise physics research. At no point was the primary lesson on commercialising any research listed – "listen to the customer".

In many cases, the customer funding the research may not want the highest quality research; rather the customer may only require enough knowledge to enter the market ahead of the competition. The customer may not want the activities protected by patents, because keeping the process a secret gives a commercial advantage – patents only tell your opposition what to do. In many cases timing the entry of a product or process into the market is critical – the market sometimes cannot wait "a long time", until the researcher has redone trials getting the technology working completely.

I have seen far too many examples of research being held onto by the researcher, who is unwilling to let go, well after provisional patents have been lodged only to find international companies "work around" the patent, and commercialise the concept, leaving the Australian company funding the research behind.

Sincerely,
Dr Malcolm Clark
MAIP
Business Adviser
Enterprise Connect Network

Dear Sir

Congratulations to all concerned regarding the changes to Australian Physics. The layout has a fresh, attractive look and the use of coloured illustrations certainly gives a visual lift. I always find the contents of considerable interest and a timely reminder of what life was all about before retirement.

Regards
Howard Pollard



Australian Institute of Physics

NOMINATIONS FOR POSITIONS ON THE AIP EXECUTIVE

Nominations are now called for the following positions on the National Executive of the AIP

**Vice President
Honorary Secretary
Honorary Treasurer
Honorary Registrar**

Those elected will take office in February 2009, after the AIP Annual General Meeting. Members are urged to take advantage of this opportunity to be involved in the election of the new officers of the AIP.

All positions are held for two years. The Honorary Treasurer, Honorary Registrar and Honorary Secretary may seek renomination at the end of their two-year term of office. The Vice President, after serving two years, takes office as President for two years.

Nominations of AIP members for these positions, proposed and seconded by AIP members, must be in writing and must include the consent of the person being nominated.

Members are requested to submit nominations to the Honorary Secretary by December 30th 2008.

By email: aip_secretary@aip.org.au

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Branch News

Victoria

Over 60 people joined an evening tour of the Australian Synchrotron on 17 July. Built on the site of a former drive-in theatre, the synchrotron is located next to Monash University and the Telstra Research Laboratories. The tour was organised by the Victorian Branch of the AIP.

July marked the first anniversary of the official opening and almost two years since the synchrotron saw 'first light'. The 3 GeV facility uses particle accelerators to produce a beam of high-energy electrons that are injected into a storage ring circulating the electrons to create synchrotron light. The light is directed down separate beamlines at a variety of experimental equipment and used to probe and manipulate matter down to the nanoscale. Synchrotrons are now an essential part of the 'tool box' of analytical instrumentation available to scientists and engineers.



Physicist David Paterson conducts a tour of the Australian Synchrotron. [Courtesy Scott Wade]

Major construction continues at the site. Five multi-million dollar laboratories have already been completed and another four are currently under construction. The facility caters for virtually all disciplines ranging from chemistry to geology and physics to medicine. Over 200 Australian and international scientists have already used the facility. By next year the Australian Synchrotron is expected to become the largest scientific user facility in the Southern Hemisphere.

The synchrotron is a good example of scientific cooperation at the national and international level. A total of 33 universities, 36 medical research institutes, all State governments and the Federal Governments of Australia and New Zealand have contributed over

\$300 million to fund the construction and operation of the Australian Synchrotron.

Tasmania

On 19 August Dr Anya Reading, University of Tasmania, presented a public lecture "Imaging the Interior of the Earth" to about 45 people. She started with an interesting comparison between the developments in the study of the Earth with other branches of physics. The first understanding of the Earth is attributed to James Hutton in 1798, but it was not until 1936 when Inge Lehmann interpreted P seismic waves as reflecting the presence of an inner core. Her work laid the foundations of the model we have today of Crust, Mantle, Outer Core and Inner Core,

Hidden structure may be investigated through a variety of physical properties such as density, magnetic susceptibility, electrical conductivity and seismic wave-speed, each working at different depths, and 3D imaging techniques used to assist in interpreting the data. Magnetic measurements, often called "Geophys" in the ABC TV program Time Team, can be used to ascertain buried building foundations and ore bodies at shallow depths. Three days of walking magnetometer surveys around the Coal Mines Historic Site in Tasmania's Tasman Peninsula enabled the extent of possible underground mining to be defined.

Electromagnetic induction is often used to locate buried conductors. Dr Reading gave the example of searching for unexploded ordnance. Up to 10% of deployed ordnance can fail to explode on impact, presenting an extremely serious problem in some parts of the world. Use of appropriate e/m frequencies can produce detectable eddy currents, so that experienced operators can deduce the size and location of targets.

At deeper depths, structure can be ascertained using seismic tomography. Solving for seismic wave-speed using the most powerful computers available enables delineation of structure at depths down to 200 km.

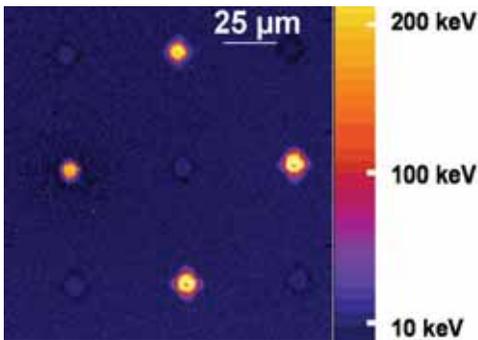
Only in the past 5 to 10 years has there been sufficient information to generate

the currently accepted model of the Earth's structure, in which a small number of hot upwellings extend from the core-mantle boundary but with the majority of 'hot spots' forming volcanic areas related to shallower temperature variations in the mantle.

New South Wales

The June meeting of the NSW branch was held at the University of Sydney on 24 June. The invited speaker for the meeting was Professor Anatoly Rosenfeld from the University of Wollongong. Professor Rosenfeld is the Founder and Director of the Centre for Medical Radiation Physics (CMRP), within the School of Engineering Physics at Wollongong University. Over the last 15 years the Centre has concentrated its research and development in the area of solid-state radiation detectors for application in Radiation Medicine, Space and High Energy Physics. This detector research and development is also well complemented by strong Monte Carlo simulation research programme. From very humble beginnings, Prof. Rosenfeld has guided and grown this research strength at Wollongong University and it is now one of the largest research Centres in Australia with a strong undergraduate Honours degree programme and over 50 postgraduate research students that are actively embarked on a wide variety of research projects. Such theoretical and experimental projects are related to studying mini-, micro- and nano-dosimetry aspects of new and emerging radiation medicine modalities including Proton Therapy and Synchrotron Microbeam Radiation Therapy. Similar research is done in other modern radiation medicine modalities including intensity modulated radiation therapy (IMRT), high dose rate and low dose rate brachytherapy and fast neutron therapy.

His talk was entitled "From the gas to the solid state Micro- and Nano-Dosimetry: Radiation Medicine and Space Applications" His talk focussed on the prediction of biological effects of ionising radiation, which is an important issue for radiation medicine and terrestrial, avionics and space radiation protection. In radiation dosimetry it is well known that the absorbed radiation dose is a surrogate



Ion beam induced charge collection image using the heavy ion microprobe of the new microdosimeter. The small active volume of charge collection is crucial if the solid-state dosimeter is to work successfully as a microdosimeter.

for the prediction of radiation effects and is applicable for low linear energy transfer (LET) radiation only. The concept of dose equivalent was introduced to better compare radiobiological effectiveness (RBE) by different ionising radiations found in new radiation modalities such as proton and heavy ion therapy as well as space radiation environments. This concept is based on measurements of pattern of stochastic deposited energies by charged particles on a cellular level in tissue represented by a sphere of 2-5 microns in diameter. This approach is called microdosimetry. Traditional instrumentation for microdosimetry is a tissue equivalent gas proportional counter (TEPC) utilizing low pressure of TE gas.

A new generation of microdosimeters substituted the TEPC by an array of micron size, silicon sensitive volumes has been originated and developed at the Centre for Medical Radiation Physics (CMRP) University of Wollongong. Discussion of these SOI microdosimeters, which were produced and investigated in a broad range of radiation fields: fast neutron, proton and heavy ions fields including hadron therapeutic oncology modalities and NASA radiation laboratory for deep space radiation effect modelling. These microdosimeters were also recently launched into space in collaboration with NASA, John's Hopkins University and the US Naval academy and Memorial Sloan Kettering Cancer Centre as part of the MiDn project (see <http://web.usna.navy.mil/~midn/>)

Prof. Rosenfeld also discussed the recent improvement in solid-state microdosimetry made possible by development of an array of 3D cylindrical SVs of several micron size with well-defined charge collection. This development was done in

partnership with semiconductor nanofabrication facility (SNF) at the University of New South Wales and the Australian Nuclear Science and Technology Organisation (ANSTO).

At ANSTO the heavy ion microprobe was shown to be an ideal tool for investigation of the microdosimeter's response on ions with a wide range of LET. Further research in solid-state microdosimetry, which is currently under development at CMRP with their partners, is a monolithic chip with array of SVs with micron and submicron size and with built in readout electronics on the same SOI chip. Fabrication will be done in collaboration with microelectronic industry utilizing 0.18 microns and 90 nm technology. Such radiation detectors will be capable of detecting charged particle radiation track features that will expand the radiobiological functionality of the microdosimeter.

Recently Prof. Rosenfeld was invited by NASA and NSBRI to be a member of a Panel on Solar Radiation Risks for Lunar Operations at International Space Medicine Summit, May 2008, Houston. The primary aims of the Summit are to foster increased communication, cooperation, and collaboration among the world's top physicians and scientists to facilitate successful human space exploration by promoting solutions that protect the health and well-being of the flight crews before, during, and after long duration missions in space; and, to enhance life on earth by applying the resultant advances in human knowledge and technology acquired through living and working in space.

According to Prof. Rosenfeld, the next stage of the research and development is a solid state, real time nanodosimetry, defined as the quantification of ionisations or energy deposited by ionising radiation within sensitive volumes of nanometer dimensions.

For applications in biomedicine the relevant sensitive volume should match the dimensions of a short segment of DNA and the surrounding medium. Ultimately this research will lead to instrumentation for the prediction of DNA damage, which will be new Australian direction in radiation protection and charged particle radiotherapy.



From left to right, Dr Fred Osman (AIP Branch Chair), Professor Anatoly Rosenfeld and Dr Michael Lerch (AIP Past Branch Chair). NSW3

News

New Chief Executive of CSIRO



The new Chief Executive of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was announced by the Minister for Innovation, Industry, Science and Research, Senator the Hon Kim Carr and the Chairman of the CSIRO Board, Dr John Stocker AO.

Dr Megan Clark has been appointed as Chief Executive of CSIRO for a five year term commencing in January 2009. She is currently the Vice President Health, Safety, Environment, Community and Sustainability at BHP Billiton.

"Dr Clark has an impeccable record as a senior executive and a wealth of experience in the development and application of science and technology, making her an ideal fit for the CSIRO Chief Executive role," Dr Stocker said.

"Dr Clark's experience brings with it a unique mix of essential skills. She has top level business development and leadership skills, a deep understanding of science and how it delivers benefits to society, and the ability to represent CSIRO on the national and international stage."

Senator Carr congratulated Dr Clark on her appointment.

"Dr Clark's experience brings with it a unique mix of essential skills." Chairman of the CSIRO Board, Dr John Stocker AO

"I look forward to working with her in her new role," Senator Carr said. "She understands the importance of innovation and the vital contribution CSIRO is making to Australia's prosperity and social well being."

The Australian Government will provide \$ 2.1 billion in direct funding to CSIRO over the next three years.

"I am very much looking forward to the new job, meeting the research and support staff and the management team, and engaging with CSIRO's research collaborators and its public and private sector partners," Dr Clark said.

"CSIRO is a tremendous organisation. Its research is an investment in Australia's future."

Dr Clark will succeed Dr Geoff Garrett who will successfully complete his term as Chief Executive on 31 December 2008. She will also be a member of the Board of CSIRO.

"This is a terrific appointment. I am really delighted for CSIRO and for Australia. We have worked closely with Megan over a number of years," Dr Garrett said. "She knows us well. I have no doubt the organisation will grow from strength to strength under her leadership."

Senator Carr said Dr Garrett will be handing over an organisation of which Australia should be proud.

"When Dr Garrett completes his term as Chief Executive he will hand over to Dr Clark a highly committed, multidisciplinary research organisation of which Australia should be proud," Senator Carr said.

CSIRO

New Chief Justice

It was announced that the new Chief Justice of the High Court of Australia will be Robert French. Justice French has a degree in physics. In his own words:

"Initially, I wanted to become a great theoretical physicist. In third year however, the dean said to me after a seminar presentation, 'you express yourself magnificently, but I am not sure you know what you are talking about'. So, I decided to become a lawyer."

"Having said that, my science degree has provided me with an invaluable

introduction into the methodology of scientific reasoning, which is of general application. There is much interaction between the law and science.

An understanding of the essentials of scientific method and the natural sciences is fundamental to anyone who wants to engage effectively in the practice of the law."
WA Branch AIP

New CEO of Qantas

The Chairman of Qantas Airways Limited, Mr Leigh Clifford, announced that Alan Joyce would become Chief Executive Officer of Qantas upon the retirement of Geoff Dixon.

Alan has been a member of the Qantas Executive Committee since October 2003 and a Director of both Jetstar Asia and Jetstar Pacific (Vietnam).

Born in Dublin, Alan moved to Australia in 1996 and now holds both Australian and Irish citizenship.

He was educated in Ireland and has an Honours Bachelor of Science degree in Applied Science (Physics and Mathematics) and a Master of Science degree in Management Science, both awarded by the University of Dublin (Trinity College). Alan is also a Fellow of the Royal Aeronautical Society.
QANTAS

Professor Robert G. Clark appointed Chief Defence Scientist

Professor Robert G. Clark has been appointed Chief Defence Scientist, the Minister for Defence Science & Personnel, the Hon. Warren Snowdon MP, has announced.

Robert Clark's early career involved 10 years' service with the Royal Australian Navy (1969-79), during which he undertook his BSc degree at the Royal Australian Naval College (Jervis Bay) and the University of NSW.

He received the EE Mayo Prize for top academic performance at the Naval College and the RAN (RNZN) Navigation Prize, going on to serve on eight RAN ships and completed an Operations and Weapons course on exchange with the Royal Navy, UK.

He was promoted to Lieutenant before leaving the RAN to complete a PhD in Physics at UNSW and the Clarendon Laboratory, University of Oxford. After a postdoctoral research position at Clarendon he was appointed University Lecturer in Physics at the University of Oxford and Fellow of The Queen's College, Oxford in 1984.

He returned to Australia in 1991 to take up the position of Professor of Experimental Physics at UNSW, where he founded and established the National Magnet Laboratory and Semiconductor Nanofabrication Facility. In 2000 he established the ARC Special Research Centre for Quantum Computer Technology (ARC Centre of Excellence from 2003), the world's largest centre devoted to this new science, and has served as its Director since then.

Over the years Professor Clark has contributed to numerous national and international bodies. These include the Prime Minister's Science, Engineering and Innovation Council's Nanotechnology Working Group, the Australian Academy of Science, the US Government Quantum Computing Roadmap Technology Expert Panel, and the Review Committee for Los Alamos National Laboratory's Physics Division.



He has the rare distinction of being awarded the Australian government's Federation Fellowship on two occasions. He has also been awarded the Australian Defence Medal and the Centenary Medal.

Last month Professor Clark won the Eureka Prize for Leadership in Science for his pioneering role in making Australia a world leader in nanotechnology and quantum computing. Quantum computers have the potential to transform society with far-reaching applications in areas such as genetic engineering, biomedical science, weather prediction, finance and security.
Defence Science and Technology Organisation

Ronald F. Davies - Father of the Modern Vacuum Pump

The Rotary Vane Vacuum Pump you use every day may seem a ubiquitous tool, but its current design owes a great deal to the engineering ingenuity of Ron Davies, who passed away in April 2008, aged 78.

Born in England, his early years were spent at sea in the Merchant Navy, transporting English passengers and cargo to Australia and New Zealand. He studied engineering and concluded his 10 years at sea with a Chief Engineer's ticket.

Australia was destined to be his home, and after marrying in New Zealand and returning to England, he migrated to Australia tasked with establishing 'Newall' - a growing UK machine tooling business. He resigned after five years and started his own business in Melbourne, manufacturing drill bushes, tube expanders, specialist tooling and universal joints. 'Jigtool Products' was born.

An approach from Monash University in the late 1960's sent Ron on a mission



to redesign vacuum pumps. Vacuum pump design had not altered in over 100 years. They were big, difficult to build, strenuous to use and near impossible to service. Ron would solve all of these problems.

Ron's concept involved shrinking the working parts into a small, integrated "cartridge" which was easy to machine, easy to bench set and simple to insert into the final oil box and motor assembly. The result, now the standard for vacuum pumps worldwide, won Ron two Australian Design Awards

- one in 1978 and another in 1990. The initial 1978 design was nominated for a Prince Philip Design Award and featured on 'The Inventors.'

Determined to make it big in Australia, Ron turned down a lucrative take over offer from a German company in the 1980's, but became the exclusive agent for the company. Ron was passionate about his technology and Australia, and when CSIRO sold a Dry Vacuum Pump design to the US he fought tirelessly to keep it in Australia. Maintaining that if it was designed in Australia it should be built in Australia.

Ron was always looking for ways to further Australian industry. When ozone depletion became a pressing environmental issue in the 1990's, Ron charged JAVAC (formerly Jigtool) with developing a solution.

Ron is succeeded by two sons, one of whom continues his visions for engineering and Australian manufacturing in the operation of JAVAC in Melbourne.
JAVAC

L'Oréal for Women in Science Fellowship

After two decades of research the first wave of nanotechnology consumer products are entering the marketplace in applications as diverse as catalysts, surface treatments for glass, cosmetics and drug delivery. But the properties that make them attractive to industry may also have unforeseen consequences. That worries Amanda Barnard, a physicist at The University of Melbourne.

"Many materials that are normally inactive—gold and silver, for example—become biologically active when the particles are just a few nanometres in size. So, if we are creating these new particles we need to understand how they will behave in the environment."

Amanda believes she can create a theoretical framework that will allow the risk of nanoparticles to be determined in the computer—before the particle has even been made. She will use her L'Oréal Australia For Women in Science Fellowship to develop new computational tools to predict the behaviour of nanoparticles in the environment.

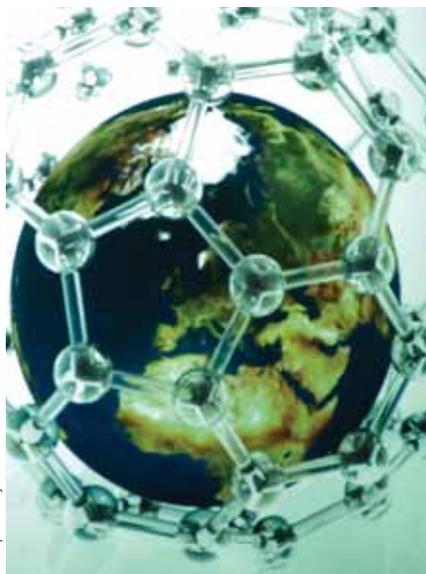
Amanda first trained and worked as a gemologist—looking in particular at diamonds and the difference between synthetic and natural diamonds. The experience fuelled her interest in physics and the rules that guide the creation of materials.

"Many man-made nanoparticles do not exist in nature. So we don't know their long term effects or how they will interact with living organisms"

After obtaining a PhD in physics from RMIT, she went first to the Argonne National Laboratory near Chicago, then to Oxford where she investigated the safety of nanoparticles and wrote a commentary on nano-hazards for Nature Materials.

She returned to Australia in 2008 to take up a Future Generation Fellowship at The University of Melbourne.

Amanda says that while nanoparticles are manufactured, stored and used under carefully controlled conditions, it is what happens to them when they are eventually discarded into landfill and waterways, under anything but controlled conditions, that is the big question.



Graphic by Amanda Barnard Photo credit: L'Oréal/SDP Photo

"Many man-made nanoparticles do not exist in nature. So we don't know their long term effects or how they will interact with living organisms," she says. But with the rapid pace of development of new nanoparticles, there are just too many to physically test under all likely conditions.

"I'm planning to build theoretical models to try to predict how the particles will behave in a wide range of chemical environments. I hope my work will help make nanoparticles safer," Amanda says.



Amanda Barnard Photo credit: L'Oréal/SDP Photo

Amanda will start with a theoretical model to predict the stability of nanoparticles in the presence of water. She will initially focus on metal nanoparticles containing platinum and palladium, which are showing great promise as catalysts to increase fuel efficiency.

Her theoretical model will look at the effects of temperature, pressure and particle size and shape on the behaviour of nanoparticles, especially their stability. It builds on past work she has done to develop a theory relating the size and shape of a wide range of different nanostructures to their stability.

Amanda will access the powerful computers she needs through the Australian Partnership for Advanced Computing (APAC) national facility and the Victorian Partnership for Advance computing (VPAC).

Her L'Oréal Fellowship will be used to purchase the software she needs to generate inputs for her models and analyse the resulting data.

Amanda hopes that her theoretical models will prove useful to nanotechnology researchers worldwide.

"We have a wonderful opportunity to learn from history here and not make the same mistakes we've made in the past with asbestos and DDT."

"Over the long term I hope that researchers around the world will be able to use my tools to predict the stability of their nanoparticles before they make them," she says.

Molecular Dynamics - A Third Way for Physics

by Nigel Marks

Prior to World War II, physics research was divided into theory and experiment, and in many respects this dichotomy persists to this day. When submitting an article to *The Physical Review*, for example, one is required to classify the manuscript as either theoretical or experimental. The advent of calculating machines, however, has changed the way that science can be performed. Drawing on both experiment and theory, a computer simulation is effectively a “virtual experiment” in which a representative version of a physical system can be studied. Through simulation one can explore systems for which analytic solutions do not exist (e.g. the N -body problem for $N > 2$, in particular $N \gg 2$) or for which the spatial and temporal scales are inaccessible to experiment. Alternatively, a simulation might consider a non-physical system (such as a universe with a $1/r^3$ gravitational force) to understand more about our own world. The computer simulation is thus a “third way” of studying physics. It uses the language of experiment and theory, and complements both approaches, yet fundamentally it is neither.

This article provides an overview of Molecular Dynamics (MD), one of the earliest and best-known categories of computer simulation. In an MD simulation a system of atoms and molecules interact for a period of time by numerically integrating Newton’s second law. This procedure consumes substantial computing resources: the integration time-step is small (~ 1 femtosecond) and the calculation of the interatomic forces at each time-step can be highly non-trivial. Correspondingly, MD simulations are limited in their spatial and temporal extent, requiring a three-way trade-off between the number of atoms in the system, the duration of the simulation and the chemical accuracy of the forces. In state-of-the-art MD simulations running for thousands of CPU-hours one might find millions of atoms, nanoseconds of simulated time, or quantum mechanically-derived forces, but never all three at once.

Historically the development of MD simulation parallels the sister method of Monte Carlo (MC) associated with von Neumann and the Manhattan project. The key difference between MD and MC is that Monte Carlo employs a stochastic approach to accumulate statistics, while MD

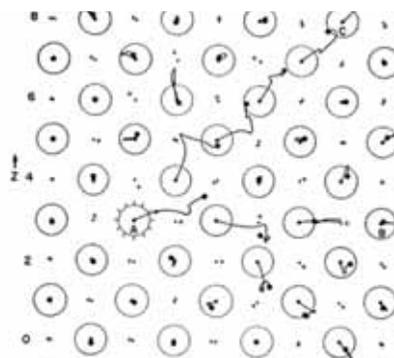


Figure 1: One of the first Molecular Dynamics simulations ever performed. In this calculation from Gibson et al., *Phys. Rev.* 120, 1229 (1960), radiation damage in copper following an energetic knock-on is visualized. Large circles give initial positions of atoms in plane; small dots are initial positions in plane below. Vacancy is created at A, focused collision sequence occurs in the direction towards C.

evolves the system via physically realistic trajectories. The first paper reporting an MD simulation was published by Alder and Wainwright in 1957. In a landmark study in which the system was modeled simply as hard spheres, they showed that the critical interactions in solid-liquid phase transitions are not the attractive forces as one might expect but rather the repulsion between atoms. Several years later, Gibson, Goland, Milgram and Vineyard performed the first “modern” MD simulations in which the forces varied continuously with position; that paper, dealing with creation of defects by radiation damage (Figure 1), continues to remain relevant nearly 50 years later.

Today, the MD community divides into two somewhat distinct camps: materials science (which includes this author) and biophysics (which does not). Generalising somewhat, the materials science community performs studies of atomic-scale processes such as surfaces, liquids, defect structures and phase-transformations, sometimes looking at atoms and clusters colliding into solids. These simulations will typically be performed in the context of associated experimental programs, often seeking to provide complementary information and/or insight. On the other side of the coin, biophysicists consider massive proteins and molecules requiring enormous simulation times to collect

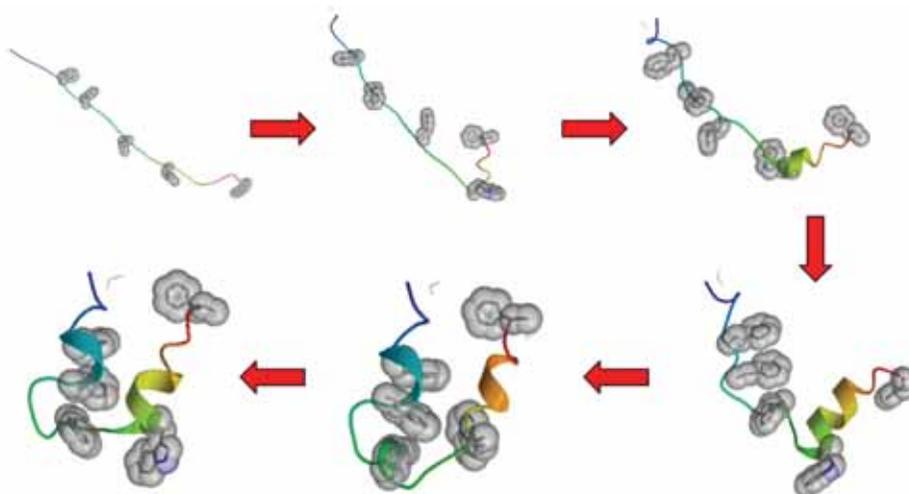


Figure 2: Molecular Dynamics simulation of protein folding. Top-left shows the unfolded villin headpiece, a small, fast-folding protein which has been heavily studied by experiment and simulation. The final folded structure is shown at bottom-left. Data from Jayachandran et al., *J. Chem. Phys.* 124, 164902 [2006] and <http://www.stanford.edu/group/pandegroup/folding/villin>.

averages. Most biophysics simulations also require aqueous environments, which further complicates the statistics. The most heroic MD simulations are of the biophysical flavour, as typified by the Stanford *folding@home* project that uses screensavers to study protein folding. In a 2006 simulation using 200,000 CPUs throughout the world, the group of Vijay Pande performed a 20,000-atom simulation of the villin headpiece, a small, 36-residue alpha helical protein (Figure 2). Incredibly, the total simulation time was 500 μ s, or 500,000 ns.

Determination of the interatomic force

Whether the calculation is in biophysics or materials science, the heart of any MD simulation is the calculation of the forces. Here the competing demands of accuracy and efficiency are at their greatest tension. On the one hand, the force (defined as the negative gradient of the potential energy U ; i.e. $\mathbf{F} = -\text{grad } U$) must have sufficient chemical accuracy for the simulation to be physically useful. On the other hand, the force routine is evaluated many millions of times, and thus cannot be too burdensome to compute. In practice, one can make surprising progress with even simple expressions. For example, in the hard sphere simulations of Alder and Wainwright, the forces were described via a step-function potential energy U equal to infinity below some cutoff, and zero elsewhere. Another simple expression which remains in use to this day, and is in fact very important for describing van der Waals interactions in biomolecules, is the Lennard-Jones potential dating back to 1931. This potential, which takes the form

$$U(r) = 4\epsilon \left[\left(\frac{\sigma}{r} \right)^{12} - \left(\frac{\sigma}{r} \right)^6 \right]$$

describes interactions between pairs of atoms, and is characterized by just two parameters. The total energy of the system is determined by summing over all pairs of atoms, and the parameters ϵ and σ (determining the bond-strength and bond-length respectively), are fitted to either experimental data or quantum chemistry calculations. When studying very large systems the potential is truncated beyond some cutoff, leading to a force calculation that scales linearly with the number of atoms N (rather than as N^2 if all pairs were included).

There are a great many other ways of calculating the potential energy of system of interacting atoms. For ionic systems one uses elegant techniques such as the Ewald method in which partitioning of the Coulomb energy into real-space and reciprocal-space components avoids the divergence of the $1/r$ summation for an infinite system. Specific analytic potentials have been developed for each major class of material (metallic, covalent and ionic) but progress has been slow. In the case of this author's area of expertise, it is only within the present decade that analytic carbon potentials have been developed to describe the graphite/diamond transition. On the most part new potentials come about through painstaking development of mathematical models guided by chemical intuition of how atoms interact. In a promising development, David Pettifor of Oxford University has shown how the Tersoff class of covalent potentials can be analytically derived from quantum mechanics, but this method has yet to provide a "magic bullet" for generic systems.

The potentials mentioned thus far are all examples of analytic potentials in which the electrons are subsumed into the mathematical description of the interatomic potential. While this approach allows fast evaluation of forces (and hence study of large systems), there are many instances where more accurate treatment of the electrons is required. In such cases, one can perform MD using a variety of quasi-quantum methods by parametrizing a simplified Hamiltonian for the valence electrons. Such methods are not typically suitable for large systems due to the matrix diagonalisation step which scales as N^3 . Somewhat confusingly, the physics and chemistry communities use very different words for the same technique, referring to this approach as tight-binding and semi-empirical, respectively.

From the generalist point of view, however, the most interesting method for calculating MD forces was put forward by Roberto Car and Michele Parrinello in 1985. They formulated a unified scheme by which MD could be performed using forces derived entirely from quantum mechanical principles. The Car-Parrinello MD (CPMD) method triggered a quantum-mechanical MD revolution; their pioneering article is the fourth highest cited paper of all time in Physical Review Letters. This author had the good fortune to work directly with the Parrinello group; Figure 3 shows a CPMD simulation of a 64-atom amorphous carbon system. The agreement with experimental diffraction data is excellent, despite the small system size [aside: finite-cell effects in MD simulations are minimised using periodic boundary conditions which eliminate unwelcome free surfaces].

Many other methods of determining forces exist, and continue to be proposed. In fact, a useful rule of thumb in computation is that half of the progress comes from the hardware (i.e. Moore's Law/Lore), with the other half provided by new algorithms and methodologies. An excellent example of the latter are the so-called QM/MM techniques that use a hybrid quantum/analytic approach. These methods are particularly useful for studying biomolecules, where only a small region is chemically active, while the remainder of the molecule influences function via structure. The QM/MM method seeks the best of both worlds by providing a quantum treatment of the active site, while employing a less costly analytic expression for the surrounding atoms. Needless to say, the devil in the details revolves around the interface between the two regions.

Numerical methods and statistical mechanics

Once the force has been evaluated for a particular atomic configuration, the position and momentum of all particles is advanced by one time-step using a numerical integration scheme. Each particle evolves according to its own differential equation, which in their simplest form are written where \mathbf{r}_i is the position of the i 'th particle, and \mathbf{F}_i is the force on the i 'th particle.

$$\frac{d^2 \mathbf{r}_i}{dt^2} = \frac{\mathbf{F}_i}{m_i} \quad (\text{where } i = 1 \dots N)$$

Perhaps surprisingly, the 4th-order Runge-Kutta method we all learn as physics undergraduates is inappropriate for MD

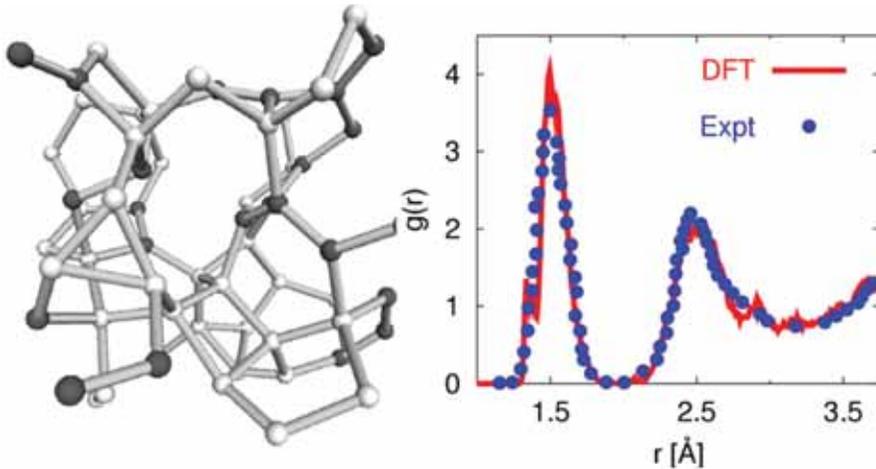


Figure 3: Car-Parrinello MD calculations of tetrahedral amorphous carbon, a diamond-like material used in hard-drives. The amorphous network was quenched from the liquid state, and was found to contain unexpected triangular and quadrilateral fragments. Agreement between the simulations and experimental neutron diffraction data is excellent. Data from Marks et al., Phys. Rev. Lett. 76, 768 (1996).

simulations, as it does not conserve total energy (potential plus kinetic) over long periods of time. Mathematically speaking, the problem with Runge-Kutta is that it is not symplectic, meaning that the integrator does not conserve volume in the position-momentum phase space.

Since energy conservation is an important attribute for a virtual experiment, many MD calculations use a Verlet-type method that provides symplectic integration. There are several variants of Verlet integrator; one of these, the leap-frog Verlet method is outlined by Feynman in his Lectures on Physics. The Verlet algorithms are both simple and subtle, being accessible to undergraduates via manipulation of Taylor expansions, yet requiring advanced mathematics to explain their behaviour. An important corollary of their symplectic character is that Verlet integrators obey the time-reversal symmetry implicit in Newtonian mechanics; changing the sign of the time-step in a Verlet-integrated system will return the trajectory to its starting configuration. The only caveat to time-reversibility is chaotic numerical instability associated with the finite precision of floating point arithmetic. On this count MD is like all deterministic systems, in which trajectories that are infinitesimally close in phase space diverge over time at a rate driven by the largest Lyapunov exponent.

One of the most popular MD integrators is the Velocity Verlet method that uses the algorithm

$$\mathbf{r}(t + \Delta t) = \mathbf{r}(t) + \Delta t \cdot \mathbf{v}(t) + \frac{\Delta t^2}{2m} \mathbf{F}(t)$$

$$\mathbf{v}(t + \Delta t) = \mathbf{v}(t) + \frac{\Delta t}{2m} [\mathbf{F}(t) + \mathbf{F}(t + \Delta t)]$$

to advance the positions and velocities one time-step Δt .

Technically speaking, energy conservation is achieved only in the limit of $\Delta t \rightarrow 0$; the use of finite time-steps in practical MD simulations results in small oscillations about an average value. Taking a pragmatic view, one usually considers the simulation is acceptable provided the energy does not exhibit a monotonic drift and that the deviations from average are not too large. In such calculations the number of particles N , the volume V , and the energy E are conserved, and the simulation is said to have been performed in the NVE statistical ensemble.

Much to the popularity of the Velocity-Verlet method derives from its transparent access to the velocities. This preferred status relates to the thermodynamic principle of equipartition in which the thermal energy of vibration is distributed equally amongst the degrees of freedom. Within MD simulations the average kinetic energy (determined from instantaneous atomic velocities) is used to define an effective temperature, and hence external manipulation of the velocities in conjunction with the Velocity-Verlet algorithm can be used to control the simulation temperature. Various methods exist for controlling the temperature in an MD simulation, with the more sophisticated methods generating the correct statistical ensemble as if the simulation were macroscopically large (and thus thermodynamically well-defined). In such cases, the temperature T is conserved, but the energy is not, and the simulation is said to be performed in the NVT ensemble.

Various other ensembles can also be constructed, the most important being the NPT ensemble in which a barostat acts to keep the pressure P constant. The NPT ensemble is particularly useful for studying phase transitions in condensed matter systems or for simulating laboratory conditions akin to a flask open to ambient temperature and pressure. For completeness it is noted that not all MD simulations use symplectic integrators. Some packages use two-step integrators using the predictor-corrector method that have very small truncation errors. Unlike symplectic integrators, however, these errors are mathematically guaranteed to accumulate, and so the user must be vigilant to ensure that conserved quantities remain within acceptable limits.

Once an MD simulation has been performed the user is faced with the task of extracting useful information from the megabytes (or perhaps gigabytes) of data describing the time-evolution of all particles in the system. This is helped to some extent by the statistical ensembles mentioned above; being able to refer simply to the "temperature" of the system is far superior to any microscopic definition of average kinetic energy. However, there are a numerous other macroscopic quantities that can be directly computed from their microscopic equivalent; two particularly useful measures are the diffusion coefficient (the coefficient of proportionality in Fick's law) and the radial distribution function (quantifying the characteristic distances between atoms). In the case of the

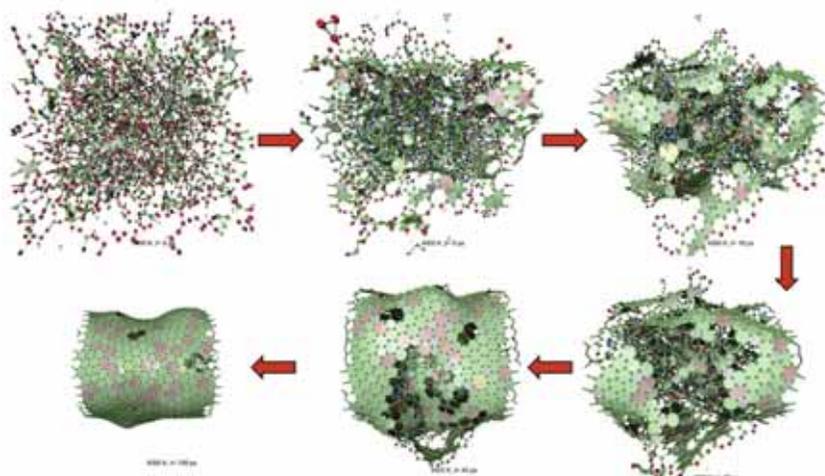


Figure 4: Molecular dynamics simulation of self-assembly in carbon. The amorphous precursor (top-left) has periodic boundaries in one direction only, corresponding to the geometry of an infinitely long nanowire. In agreement with experiment, high temperature annealing results in the formation of sp^2 -bonded carbon that arranges into multi-wall nanotubes (bottom-left). Data from Powles et al., Phys. Rev. B (submitted).

latter, experimental techniques such as neutron, electron and X-ray diffraction directly probe this information, enabling direct comparison and interpretation between experiment and simulation (as seen in Figure 3).

The simulations can also determine lattice parameters, crystal structures and phase boundaries, bulk moduli, elastic constants and a variety of other structural quantities that can be directly compared to experiment. Additionally, there is the unique insight provided by MD itself, namely the raft of structural and dynamic information that is typically unavailable to the experimentalist due to instrumental constraints. This information is usually visualized using 3D animation sequences, providing invaluable insight and feedback into the scientific process. Figure 4 shows an example of this process, illustrating the temperature-driven self-assembly of an amorphous carbon nanowire into a multi-wall carbon nanotube.

Philosophy and pedagogy

The portrayal of MD as a “virtual experiment” reflects an interesting philosophical perspective. Since all of the physics that enters the simulation is placed there by the user, one has the ability to determine whether or not a particular set of physical principles is sufficient to explain an experiment of interest. In this sense, an MD simulation can be considered as a “white box”, in which the description of physical reality is necessarily incomplete, but at least the user knows exactly what is in the box. In contrast, a laboratory experiment is to some extent a “black box”, in which small details (perhaps crucial ones) lie hidden from the experimentalist, perhaps due to technical difficulties, or maybe simply to a lack of awareness that a particular parameter or quantity has an important physical effect. The MD practitioner has the advantage that a minimal set of known physical principles can be used to study a system; if the behaviour does not match experiment, further physics or chemistry can be added. For a recent example of this Einstein maxim “as simple as possible, but not simpler”, see the online MD simulations of Lau et al., Phys. Rev. Lett. 100, 176101 (2008).

From a teaching perspective, MD also has much to offer. For example, one can teach planetary motion, conservation of energy, linear momentum and angular momentum to undergraduates; from personal experience this author

guarantees that they will enjoy the experience. One can also illustrate complex mathematical concepts such as the symplectic integrators by simulating a pendulum with the Runge-Kutta algorithm and watching it gradually slow to a standstill due to the non-conservation of energy. In statistical mechanics and thermodynamics one can model phase transitions in solids, liquids and gases, thereby illustrating fundamental relationships that are traditionally taught only from an analytic or experimental perspective. Conceptual concepts such as heat flow that involve the connection between the microscopic and macroscopic come alive when the student is faced with the “conflict” between the arrow of time and the time-reversibility of microscopic Newtonian dynamics. Finally, MD simulations are naturally amenable to visualisation, and thus the teacher has another tool at their disposal during class times and when setting assignments. These meta-considerations of scientific practice and teaching remind one of Feynman’s famous quote regarding the atomic hypothesis:

If, in some cataclysm, all scientific knowledge was to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis (or atomic fact, or whatever you wish to call it) that **all things are made of atoms — little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another.** In that one sentence you will see an enormous amount of information about the world, if just a little imagination and thinking are applied.

One cannot help but think that molecular dynamics would be a crucial part of that imagination and thinking.

Further Reading and Information continued on page 180

A/Prof Nigel Marks is a computational physicist with 15 years of experience performing molecular dynamics simulations. He recently moved to Curtin University of Technology to take up a fellowship within the Nanochemistry Research Institute.



Australia and the Large Hadron Collider

by Stephen Pincock
Science in Public

In a circular tunnel beneath the border of France and Switzerland, scientists have begun one of the most ambitious scientific projects ever undertaken. Half a world away, researchers in Melbourne and Sydney who have played a crucial part in the enormous collaborative effort are watching in great anticipation.

The Large Hadron Collider, the world's largest particle accelerator complex, will smash together sub-atomic particles that have been accelerated to dramatic speeds, with the aim of understanding the basic forces of nature that have shaped our universe since the beginning of time.

"It really is very exciting," says Professor Geoffrey Taylor from the University of Melbourne, who has been working on the project since its beginnings in the early 1990s. "We know we're on the cusp of something significant."

The Large Hadron Collider (LHC) will recreate, on a minuscule scale, conditions very similar to those that existed soon after the Big Bang. Its main purpose is to explore the validity and limitations of the Standard Model, the current theoretical framework for how physics operates at the most fundamental level.

The LHC was built by the European Organization for Nuclear Research, but has been funded, designed and constructed in collaboration with scientists from around the world. At last count, the project has involved more than eight thousand physicists from universities and laboratories in 85 countries.

"We know we're on the cusp of something significant"

It has been more than twenty years in the making, says Professor Taylor. The idea first arose in the early 1980s and the CERN Council approved the project in December 1994.

After a long process of planning, design and construction, the first attempt to circulate a beam of protons through the entire LHC was made on 10 September 2008. The first high-energy collisions are expected not long after, on 21 October 2008.

Deep beneath the Earth

The collider is housed in a circular tunnel 27 kilometres long, at a depth of between 50 and 175 metres below the ground. The tunnel, 3.8 metres in diameter and lined in concrete, was actually built in the mid-1980s to house an earlier collider. It straddles the border between Switzerland and France, although most of it is in France.

"The big thing about the LHC is that it collides the protons at much higher energy than other colliders," says Dr Kevin Varvell from the University of Sydney, another LHC collaborator. "It gives us much more reach really, and brings us a little bit closer to the Big Bang. We hope that it will fill in some missing gaps in our understanding of subatomic physics."



ATLAS beam pipe installation
Photograph: Maximilien Brice ©CERN

The LHC's collider tunnel contains two adjacent pipes, each of which contains a beam of protons (a proton is one type of hadron). The beams travel in opposite directions around the ring, kept on path by more than 1600 superconducting magnets, most of which weigh more than 27 tonnes.

Once or twice a day, the protons will be accelerated to an energy of 7 tera electron-volts (TeV), giving a total collision energy of 14 TeV. At that point, the protons will take less than 90 microseconds (that's ninety millionths of a second) to travel around the ring.

As the particles smash together they will 'break apart' into smaller, more fundamental components, giving physicists a fleeting chance to observe those particles, some of which will never have been seen before.

"We know we are likely to find something very important, something scientifically quite profound," Professor Taylor says.

One of the most highly anticipated products of the collider might be the elusive Higgs boson, which could explain how other elementary particles acquire properties such as mass. If scientists can verify the existence of the Higgs boson, it would be a significant step in the search for a Grand Unified Theory, which aims to bring together three of the four known fundamental forces: electromagnetism, the strong nuclear force and the weak nuclear force, leaving out only gravity. In addition, scientists hope the LHC could reveal supersymmetric particles, micro black holes or even extra dimensions.



The ATLAS detector: Australia's role

Scientists from the University of Melbourne and the University of Sydney have jointly contributed to one of the six detectors at the LHC. Their contributions include designing detectors and shielding, developing software to model the behaviour of the detector, and software that triggers the collection of information.

Around the ring of the LHC are positioned 6 detectors, which have been designed to search for the new discoveries revealed as the protons collide. Australia's physicists have been most closely involved in the development of one of these detectors, known as the ATLAS experiment. The Australian Government, through the Australian Research Council, has supported them.

ATLAS, itself the product of a worldwide collaboration, is roughly 45 meters long, more than 25 meters high, and weighs about 7,000 tons, making it about half as big as Notre Dame Cathedral in Paris.

"Bigger is not necessarily better, but in this case it's the only way we can do this kind of science because of the instruments we need," says Dr Varvell.

The sophisticated technology incorporated into this device is designed to detect "anything new within reason, and to allow us to be fairly sure we will see what we expect," he says.

If all the data from ATLAS was recorded, it would fill 100,000 CDs per second, the project scientists say, which is enough to create a stack of CDs 450 feet high every second, reaching to the moon and back twice each year.

Fortunately, not all the data is collected, and ATLAS will actually only record data that might show signs of new physics—"only" 27 CDs-worth per minute.

Interconnections on the last sector of the LHC
Photograph: Maximilien Brice ©CERN



Australia's scientists were particularly involved on the radiation resistance of silicon detectors in the centre of ATLAS. Challenges included designing technology that would function at the extreme conditions generated in the LHC. "The biggest issue was the intensity of the machine, which is more than 1,000 times higher than current machines," said Professor Taylor.

"It wasn't that long ago that we didn't even know that atoms existed"

"The speed of the read-out will also be 10,000-15,000 times higher. We had to do a lot to make the detectors viable." Australian companies were also involved in constructing copper shields that form part of the machine, and in 2003 Professor Taylor's team supervised the despatch of 14 pieces of shielding to LHC, weighing some 35 tonnes.

Do we need it, and is it safe?

The discoveries that will be made by scientists working at the LHC will rewrite our understanding of how the universe began and the way it operates at the most fundamental level, says Dr Cathy Foley, President of the Australian Institute of Physics.

"It wasn't that long ago that we didn't even know that atoms existed," she says.

"That discovery allowed us to do all manner of things that people couldn't have dreamed possible before. If thanks to the work at the LHC we're able to understand subatomic particles, it will surely lead us to new technologies or ways of understanding the world around us. We will look back in 100 or 200 years and marvel at how antiquated are the things we can do today."

Taking part in such an enormous collaborative project is an important opportunity for Australian physicists to take their place in a global scientific endeavour, Dr Foley said.

"Also, from a political point of view, being part of such a big project says we want to collaborate with colleagues around the world in a way that can break down political barriers. That's extraordinarily powerful."

She also dismisses the fears that the LHC will create a black hole that will somehow swallow up the earth. "The LHC will replicate collisions that already occur naturally when Earth runs into the path of high-energy cosmic rays," she says.

Although the particles will be smashed together at speeds that generate large amounts of energy in sub-atomic terms, when you compare it to more everyday events they are less impressive, she notes.

"Each collision of a pair of protons in the LHC will release an amount of energy comparable to that of two colliding mosquitoes," she says. "It's like a rice-bubble pop."

Physics Enrolments - more good news

by Philip Jennings, John de Laeter, Marjan Zadnik and Bob Lloyd

Abstract

After nearly a decade (1994 – 2001) of declining physics enrolments in Australian Universities, which led to the closure or amalgamation of many university Physics Departments, and reported declines in the number of secondary school students studying Physics, tertiary level enrolments have risen sharply in the past seven years, which is indeed good news, not only for the physics community, but for Australia as a whole.

During the period of the last enrolment survey, covering the years 2003 to 2005, third year Physics enrolments increased some 42 % over the preceding triennium. There were also encouraging signs of enrolment increases at the post-graduate level, but not at fourth year. This renaissance in physics enrolments was brought about, in part, by the diversification in applied physics courses such as nanotechnology. The question then being asked by physicists was: Would the good times continue?

The question can now be answered in the affirmative. In the recently completed enrolment survey covering the period 2006 to 2008 (the fourteenth in the series which commenced in 1974), significant increases in enrolments are reported at all levels, as compared to the 2003 to 2005 survey. The third year numbers have stabilized over the past three years at 11% above the total for 2003 - 2005, while the respective increases are 26% for fourth year and 20% for post-graduate enrolments. It is particularly pleasing to see the increases at the post-graduate level as this will have an impact on the research performance of Physics Departments at a time when physics research is of vital importance to Australia. The increases in post-graduate numbers, which have shown progressive improvements since 2002, are likely to continue, at least for the immediate future, due to the flow-on effect from healthy third and fourth year enrolments.

It is however sobering to reflect on the fact that Australian enrolments at both the fourth year and postgraduate levels have only just returned to the numbers reached in the early nineties.

New Zealand Physics departments did not suffer the same declines in the late nineties as their Australian counterparts and consequently the enrolment increases over the past six years, which we have seen in Australian Universities, have not been reflected in New Zealand. Their numbers have remained stable or increased slowly, in line with the trends observed over the past fifteen years.

Introduction

This is the fourteenth of a series of triennial surveys of physics enrolments in Australian and New Zealand Universities. This project began in 1974 with surveys by Watson-Munro [1] and de Laeter [2] for physics enrolments at Australian Universities and Colleges of Advanced Education respectively in the period 1963 to 1973. The original aim of the surveys was to collect data for planning purposes and to study the effects of Government policy on the physics profession.

In 1975, de Laeter and Watson-Munro [3] produced the first of their combined surveys for all Australian tertiary educational institutions covering the period 1965-1975. They repeated the exercise in 1979 [4]. Following the retirement of Professor Watson-Munro in 1979, Philip Jennings and John de Laeter combined to continue the surveys at triennial intervals through the eighties [5,6,7,8]. In 1993 the survey was expanded to include New Zealand Universities and Graeme Putt joined the team [9,10,11,12,13]. Following his retirement, Bob Lloyd has taken over the New Zealand survey. Marjan Zadnik has joined the team for this survey with a view to him taking over the Australian survey from 2011.

We now have a consistent set of data covering the period 1968 to 2008 for Australian Universities and from 1991 to 2008 for New Zealand Universities.

Originally, the surveys focused on the numbers of third and fourth year physics students. These were easier to identify than graduates in physics, as some students study double majors or double degrees, which are difficult to keep track of while others graduate at mid-year. Although it is easier today to collect the data on physics graduates because it is

required by the Federal Government, we have continued to count third and fourth years physics enrolments for historical consistency. They also represent a more realistic estimate of the class sizes in physics rather than the output of Physics Departments.

Beginning with the 1982 survey, we began to collect the total number of postgraduate students in physics. Here again we chose to count the total number of postgraduate students to gain an indication of the size of the postgraduate effort. In earlier surveys [6,7,8] we also estimated the number of pass, honours and higher degree graduates each year.

In 1991, we also began to address gender issues, because of the perceived low level of participation by females in physics. Initially there was some difficulty in obtaining this information, but we now have sufficient data to draw conclusions, and as time goes by, we are able to study trends in participation rates of males and females.

Methods

Starting with the 2002 survey, in addition to collecting data about third year, fourth year (Honours and Diploma) and postgraduate (MSc and PhD) enrolments, we asked a set of questions about recent changes in course content and structure, and the administration of the physics courses in the various Universities. We also sought information about changes planned for the near future, changes in the student population, and significant problems facing the Departments. We have continued this practice in the two subsequent surveys.

The data was obtained from the Heads of the various Physics Departments in Australian and New Zealand Universities.

We have tried to ensure that the data are consistent and accurate by circulating the Tables to Heads for checking. However, there are certain to be minor errors due to changes in enrolments during the academic year and these are often corrected in the subsequent survey. The gender data for Canterbury University has been estimated because they were unable to disaggregate it. We discovered an error in the reporting of some earlier data from the University of Auckland and that has been corrected as far as possible in this paper. All Physics-related courses that have been accredited by the AIP, or have 50 % or more Physics content, have been included in the statistical data in Table 1. We encourage readers to notify us if they detect any errors in the data. (All Tables can be found on pages 172 - 174)

Analysis of Enrolment Data

The third year, fourth year and postgraduate enrolments for the period 2003 to 2008 are presented in the Appendix as Tables 1, 2 and 3 respectively. Figures 1, 2 and 3 show the trends in total enrolments at third year, fourth year and postgraduate level over the 41-year period since data collection began in 1968. The following observations are made on this data:

Third Year Enrolments

The data presented in Table 1 are the numbers of students enrolled in a third year physics unit/paper at Australian and New Zealand Universities that offer an accredited Physics course. They include students who are studying Physics as a major or minor area of interest. Full time and part time students are counted as whole numbers as we are interested in the number of students taking some Physics at third-year level in any given year. This definition has been used since the inception of these surveys.

Australia

Twenty-six Universities are now offering some sort of undergraduate Physics degree compared with 32 at the peak in 1993. However 25% of these have very small numbers and are still under threat of closure. Table 1 shows that only ~25% of the physics courses are large and stable. Two Physics Departments (UWS and Victoria University) have discontinued their degree courses during this survey period.

The graph in Figure 1 shows that a steep decline in third year enrolments began in 1993 and ended in 2001 with a strong recovery from 2002 - 2005. This is apparent in all States but is not present in the New Zealand data. The dip and recovery is present also in the fourth year and postgraduate data for Australia.

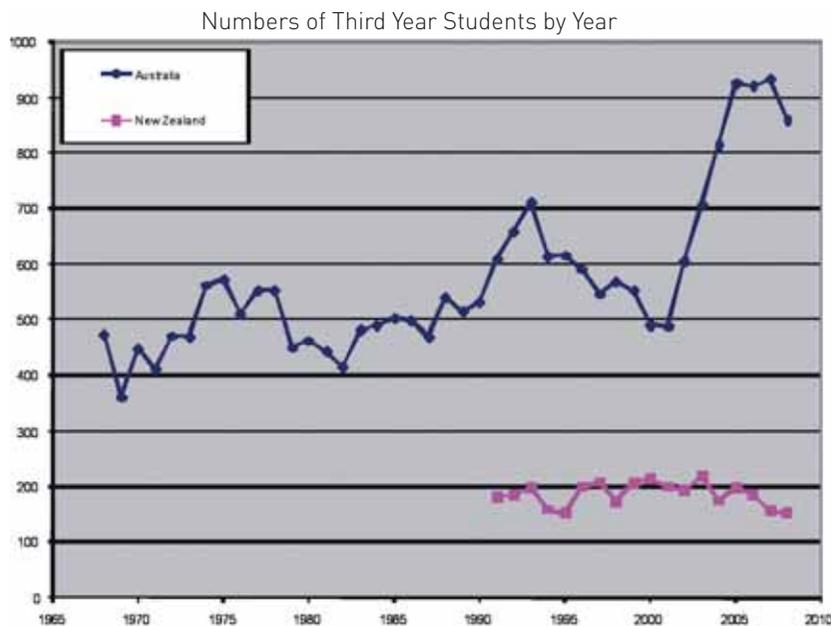


Figure 1: Numbers of Third Year Students in Australian and New Zealand Universities 1968 - 2008

This seems to indicate that it was due to specific Australian factors such as funding cutbacks, increased student fees, restrictions on overseas students, and changes to the high school curriculum.

The strong recovery in Australia between 2002 - 2005 seems to be associated with the diversification of Physics offerings (eg. nanotechnology, photonics and medical physics). Since 2005 enrolment numbers have grown more slowly and some restructuring is underway in many Universities as they reassess the new offerings. In WA the third year numbers are still growing and this could reflect economic conditions arising from the minerals boom.

Female numbers have risen over the survey period but not as fast as males. As a result the female participation rate in physics has dropped from 23% in 2003 to 17% in 2008.

It is important to note that there are some ambiguities in the reporting of these numbers due to the difficulty of distinguishing physics majors from minors and service users.

New Zealand

Six New Zealand Universities offer a degree in Physics, the same as in 1993. Third year Physics enrolments have declined slightly (~15%) over the current triennium compared with the previous one. The percentage of females has remained at about 20% of the total third-year enrolments during this triennium, which is quite close to the Australian long-term average.

The participation rate of University students in third year Physics is quite similar in Australia and New Zealand, as can be seen in Table 1. Australia's population is roughly five times that of NZ and Australian third year enrolments are on average about five times as large as those in New Zealand. The major difference is the large fluctuation in enrolments in Australia compared with the relatively stable pattern in New Zealand.

Fourth Year Enrolments

Table 2 represents the numbers of students enrolled in a fourth-year Physics unit/paper at an Australian or New Zealand University. These numbers include honours, graduate diploma and graduate certificate students. Full time and part time students are all counted at full value as the numbers are

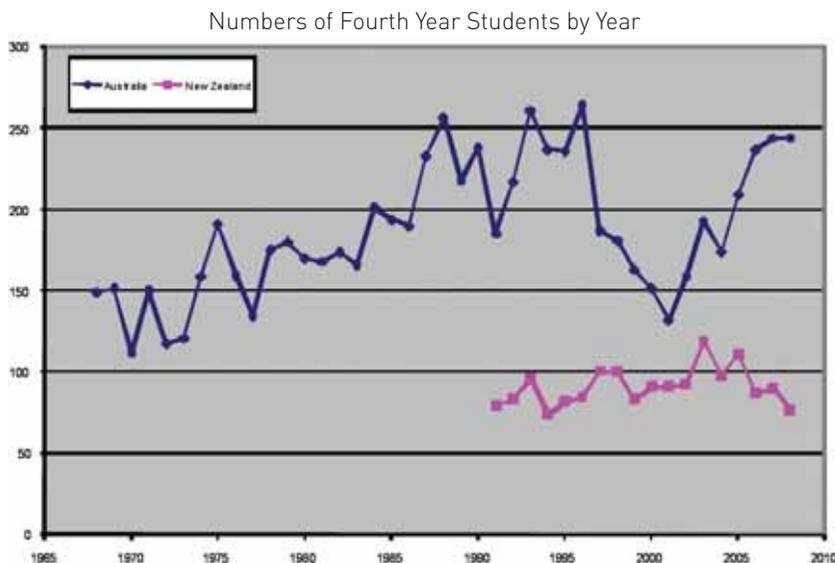


Figure 2: Numbers of Fourth Year students in Australian and New Zealand Universities 1968 - 2008

meant to indicate how many individuals are involved in fourth-year Physics studies in any given year.

Australia

The fourth year enrolment numbers are shown in Table 2 and Figure 2. A steep decline in enrolments began in 1995 and ended in 2000. A strong recovery began in 2001 and continued to 2006, after which more modest growth has continued. The fourth year numbers are now almost back to the levels of the early nineties.

An analysis of Tables 1 and 2 indicates that about 30% of third year physics students continue on to fourth year studies. The number of females in fourth year has risen since 2001, but not as fast as male numbers. Hence the participation rate of females has dropped from 24% in 2000 to 19% in 2008.

Despite the recovery, less than 25% of the Universities had strong and stable honours classes – more than half had less than 5 students in honours in 2008.

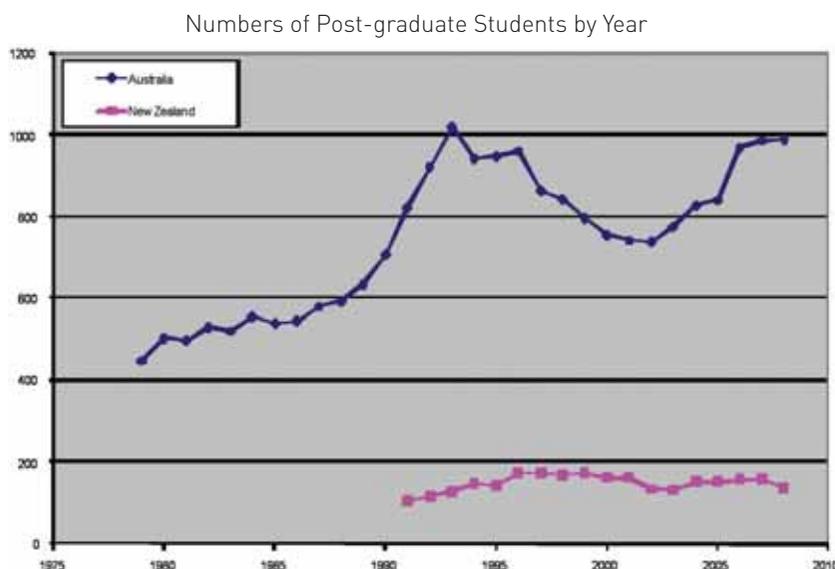


Figure 3: Numbers of Postgraduate students in Australian and New Zealand Universities 1980 - 2008

New Zealand

There was a noticeable decline in enrolments in fourth year over the period 2003 – 2008 following substantial growth in the early years of this decade. The gender balance has remained relatively stable over the past decade and is similar to that for third-year units, and slightly lower than in Australia. The participation rate in fourth year courses in New Zealand is higher than Australia, in contrast to the third year numbers. This is a result of a higher retention rate between third and fourth year in New Zealand, where about 50% of third year students stay on for fourth year studies, compared with 30% in Australia.

Postgraduate Enrolments

Table 3 represents the numbers of individual students involved in postgraduate studies in Physics in Australia and New Zealand. It includes PhD, Masters by research and coursework and postgraduate diploma students. Full time and part time students are both included at full value as the aim is to determine how many individuals are involved in postgraduate studies in any given year.

Australia

Table 3 and Figure 3 show that a decline in physics postgraduate enrolments in Australia began in 1993 and ended in 2002. This decline was followed by a strong recovery, which began in 2003 and is still continuing, although it has leveled off somewhat since 2006. Despite the recovery, the postgraduate numbers have not returned to the peak level reached in 1993. The fall and rise in Australian postgraduate numbers resembles that occurring in the third and fourth year enrolments shown in Figures 1 and 2. It is interesting to note this fluctuation did not occur in NZ. The reasons are probably linked to the introduction of HECS, limits on PhD scholarships and funding periods and the introduction of full fees for Masters by coursework and international students in the early nineties. The effect is clearly an Australian one as it occurred simultaneously in all States, but not in NZ.

Female postgraduate numbers have risen strongly since 2003 but have not kept pace with male numbers and the female participation rate has dropped slightly from 23% in 2000 to 21% in 2008.

New Zealand

Postgraduate physics enrolments in NZ have recovered after dropping slightly from the relatively higher numbers of the previous decade. Some of this decline can be attributed to government funding for PhD students,

progressively reducing from a 6 year to 4 year maximum. Whatever the reason, it seems to have been addressed and numbers of postgraduates are now back to the levels of the late nineties.

The gender balance for postgraduate Physics has risen slowly over the past decade; in the present triennium it is 22.5 % females, similar to the Australian figure. The postgraduate participation rate in NZ is similar to that in Australia.

Overall Comments

In Australia, Physics enrolments at all levels have recovered well from the decline in the late nineties and the numbers

in all categories are now close to or above their previous peaks, reached in 1993. There is some indication of a slowing growth since 2005 and some restructuring of departments and courses is now underway. Many Australian Universities still have small numbers in third and fourth year, with large annual fluctuations. Female participation rates have declined slightly, despite efforts to encourage greater female enrolments.

There have been no major changes in NZ over the survey period. Physics enrolments are declining at third year level, increasing at fourth year and stable at the postgraduate level. Female participation in NZ is slightly lower than in Australia.

Analysis of the Questionnaire Data

In addition to the enrolment data, we collected responses to six questions. A content analysis was carried out with the results summarised below:

Question 1: Describe any major changes to your educational offerings in Physics over the past five years (eg new directions, new awards, termination of courses, etc)

Australia

- New courses have been introduced in nanotechnology (5), nuclear science (2), medical physics (2), astrophysics (2), Master of Philosophy (2)
- Small courses were cancelled (8): these were mostly in photonics
- Small units in physics were cancelled (6)
- Major restructuring of degree course (6)

New Zealand

- Auckland University has introduced a new first-year paper for biomedical students and a new program "Bachelor of Technology in Medical Physics and Imaging Technology" plus non-specialist general education papers in astrophysics and sustainable energy.
- Victoria University introduced an engineering component in 2007, including electronic and computer engineering.
- Canterbury has initiated two new physics-based courses (Electronics and Medical Physics)
- Waikato: The introduction of the BE degree has resulted in a number of new electronics-based units.

Question 2: What do you consider are the major successes or achievements of your Department in teaching and student recruitment over the past five years?

Australia

The main responses were:

- Improved recruitment due to new offerings (8)
- Increased postgraduate enrolments (4)
- Improved retention rates (3)
- Awards and prizes received for research or teaching (2)

New Zealand

- Auckland University has large numbers in its general education papers at first year level and in its biomedical papers.
- Victoria University has introduced an extended outreach program.

- Canterbury University has succeeded in holding on to a physics unit in the Engineering Intermediate Year.
- Massey University has succeeded in stabilising student numbers overall after five years of decline, and increasing their postgraduate numbers.

Question 3: Are there any major changes planned in your educational offerings in the next three years?

Australia

- Thirteen departments indicated no major changes planned.
- Major restructuring of degree program (6)
- Further cutbacks on small units (4)
- General first year/integrated science course (5)
- New course proposals (4)

New Zealand

- Victoria University indicated that a major in applied physics and a possible involvement in an environmental science major is under discussion
- Massey has plans for a new major in Nanoscience, which is a joint course with Chemistry. This will be offered at Palmerston North campus initially from 2008, and then at Albany (Auckland) from 2010. They are also investigating the possibility of a biophysics major.
- Waikato: Theoretical physics staff will probably take a more active role in the teaching of mechanical engineering and the third-year quantum physics (solid state) unit will be customized to meet the needs of these students.
- Otago will be changing from individual subject based units to full semester units in 2009.

Question 4: Have you observed any substantial changes in the Physics student population at your University over the past five years? (eg change in gender balance, change in quantity or quality of students, changing age profile, etc)

Australia

Ten departments reported no major changes, while others reported:

- Lower numbers of undergraduate physics students (5)
- Weaker students (3)
- More females (2)/ fewer females(2)
- More part-time students (4)
- More double majors (2)
- More postgraduate students (7)
- More overseas postgraduate students (2)

New Zealand

- Auckland University has fewer international students but more students are undertaking one-semester internships.
- Victoria University reported an increasing number of graduate students
- Canterbury is recruiting excellent numbers of female students into astronomy.
- Massey has more part-time students, and students taking longer to complete undergraduate degrees. Decline in quality may be an issue. Fewer students are taking electronics options
- Waikato has fewer top-level students than before.
- Otago is still attracting good students.

Question 5: Have there been any significant changes to the administration of your Physics degree over the past five years? (eg mergers, closure, etc.)

Australia

Thirteen departments said that there had been no significant changes in the administration of their physics degree over the past three years, but all the other universities have experienced substantial changes. The most common were:

- Mergers with engineering (4)
- Closures (2)

New Zealand

- Auckland University has introduced a standard eight-paper per year course with almost every paper being completed in one semester.
- Victoria University has introduced a Graduate Diploma in Physics.
- Waikato: The physics department is now part of the Department of Engineering but it still offers a major in physics.

Question 6: What do you consider are the most significant problems facing your Department at this time? (eg declining enrolments, lack of junior staff, etc)

Australia

Four Universities said that there were no significant problems facing their Department. The remaining Universities listed a wide variety of issues of concerns. These are listed below in descending order of frequency of response.

- Excessive workloads (14)
- Lack of senior staff (5)
- Ageing infrastructure (5)
- Shortage of funds for research (4)
- Lack of technical support (4)
- Declining enrolments (4)
- Cuts to small units (3)
- Constant threats of closure (3)
- Constant change to structure and administration (3)
- More casual contracts for staff (2)
- Lack of junior staff (3)

New Zealand

- Auckland University reported that there are insufficient younger, junior staff and that this was restricting their ability to increase research income and postgraduate student enrolments.

- Victoria University reported administrative workloads are increasing as the focus on university management increases; an ageing senior laboratory infrastructure, generational change as a cohort of experienced personnel reach retirement.
- Canterbury noted the retention rate from first year to second year students is very poor and there are declining postgraduate numbers. New management styles in universities have created layers of administration and oversight without purpose. Constant requests for information or to do tasks take staff away from the core-values of research and teaching. Meanwhile the accountability for the traditional tasks (research and teaching) have increased (performance based research funding, teaching surveys).
- Massey: The most significant problem is loss of staff. With constant student numbers rather than growth, the student/staff ratio is starting to hurt, as is the staff workload (same number of teaching hours but fewer staff to share them out). Performance based research funding has put more pressure on staff.
- Waikato: Declining enrolments and loss of physics majors to the BE program
- Otago: Increasing administrative load, move to funding from performance based research funding rather than student numbers, high workloads.

Many Departments have experienced a substantial increase in enrolments following serious declines in the late nineties

Conclusions

The past six years have been a time of growth and consolidation in Physics education in Australia and New Zealand. Many Departments have experienced a substantial increase in enrolments following serious declines in the late nineties. In 2008, Physics enrolments at the third year, fourth year and postgraduate levels stabilized at close to their highest ever numbers, after a period of sustained growth since the minimum in 2001. Some rationalization of courses is still occurring and some of the smaller departments are still facing threats of mergers or closure. However a majority of departments are experiencing rapid growth which is causing workload stress in many cases and have reported a need for additional technical support and infrastructure and equipment replacement/renewal. Innovation in courses and research has continued and new offerings have appeared in nanophysics, astrophysics, medical physics and nuclear technology. There has been some reduction in photonics courses after the surge of interest in the nineties.

The outlook for the future of Australian Physics is as optimistic as it has been for the past thirty years. The recovery in this decade seems to be holding and departments expect modest increases in enrolments at all levels over the next few years. There are challenges ahead in providing modern infrastructure, adequate staffing and research funding but the signs are positive that Governments are beginning to understand these needs and will respond.

Over the corresponding, period New Zealand Physics has experienced relatively stable enrolments, however a modest decline has appeared in third and fourth year enrolments over the past triennium. Workloads, however have been increasing and recruitment of younger staff is constrained, nevertheless, innovation is occurring and substantial changes in administration and course content are underway. The female participation rate in Physics in Australia and New Zealand is still very low (~20%) despite efforts to improve it over the past decade.

Acknowledgements

The authors are indebted to our colleagues in the various Universities of Australia and New Zealand who have supplied us with the data and checked the Tables for us.

Note

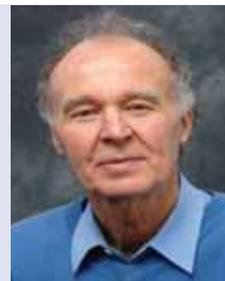
The authors of this article are different from the last enrolment report, in that Graeme Putt from the University of Auckland has retired, and been replaced by Bob Lloyd from the University of Otago, and Marjan Zadnik from Curtin University has joined the two long-serving Australian co-authors. It is the intention of John de Laeter (who has been involved with this project since its commencement), and Philip Jennings (who joined the project in 1980), to cease their involvement in the project following this survey, and they have designated Marjan Zadnik, who is a specialist in Physics Education, to be the senior Australian author of the next survey. We are confident that this enrolment project will successfully continue to provide essential data to the physics community, as it is an excellent indication of the “health” of physics in Australia and New Zealand.

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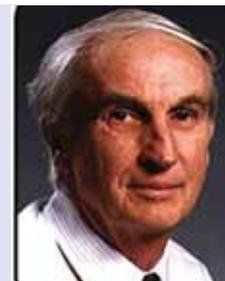
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Tables 1, 2 and 3 can be found on pages 172, 173 and 174 respectfully.

Philip Jennings is Professor of Physics and Energy Studies at Murdoch University and his research interests are in surface physics and photovoltaics.



John de Laeter is Emeritus Professor of Physics at Curtin University of Technology. His research interests are in mass spectrometry applied to nuclear, geological and chemical problems, but he has also had a long-standing interest in science education.



Marjan Zadnik is an Associate Professor at Curtin University of Technology and his research interests are in Physics Education and Astronomy. He has won several national awards for teaching excellence.



Dr Bob Lloyd is the Director of Energy Studies at Otago University. His interests lie in energy conservation in residential housing and energy management including world energy resources.



Table 1
Physics Enrolments in Australian & New Zealand Universities 2003 - 2008
Numbers of Third Year Physics Students

Institution	2003		2004		2005		2006		2007		2008	
	M	F	M	F	M	F	M	F	M	F	M	F
Griffith University	12	3	10	3	19	3	18	1	20	2	12	1
James Cook University	5	2	4	6	7	1	3	2	4	2	9	0
Queensland University Technology	9	5	16	4	15	5	10	2	9	2	15	2
Central Queensland University	4	0	4	0	5	0	2	0	1	1	2	0
University of Queensland	11	3	12	5	12	5	46	11	48	15	41	7
University of Southern Queensland	6	3	5	3	4	3	3	1	3	0	1	2
Total Queensland	47	16	51	21	62	17	82	17	85	22	80	12
	63		72		79		99		107		92	
Macquarie University	25	1	10	5	15	1	20	4	14	3	11	4
University of Newcastle	21	5	38	3	34	4	33	6	27	5	33	6
University of New England	7	1	3	0	3	0	6	3	6	1	7	2
University of New South Wales	69	19	90	18	107	21	96	15	103	15	88	10
University of Sydney	56	12	51	15	73	22	58	14	76	21	66	20
University of Technology, Sydney	11	1	18	1	24	2	21	1	12	4	26	5
University of Western Sydney	11	4	11	8	0	0	0	0	0	0	0	0
University of Wollongong	28	8	21	4	30	9	46	8	40	21	39	8
Total New South Wales	228	51	242	54	286	59	280	51	278	70	270	55
	279		296		345		331		348		325	
Aust. Defence Force Academy	10	2	18	6	12	3	18	2	8	2	23	3
Aust National University –Faculties	33	11	36	15	49	10	51	13	47	10	35	10
Total ACT	43	13	54	21	61	13	69	15	55	12	58	13
	56		75		74		84		67		71	
La Trobe University	9	3	17	1	18	4	14	3	12	2	7	5
Monash University	24	6	28	6	36	13	31	6	25	4	36	7
Royal Melbourne Inst Technology	32	4	29	5	35	4	21	3	23	4	27	2
University of Melbourne	50	19	57	22	32	35	95	30	90	25	71	22
Swinburne University of Tech	0	0	11	1	15	3	7	0	10	1	7	0
Victoria University	23	3	14	3	4	2	1	0	0	1	0	0
Total Victoria	138	35	156	38	140	61	169	42	160	37	148	36
	173		194		201		211		197		184	
University of Tasmania	20	2	20	2	23	2	21	5	23	2	5	0
Total Tasmania	22		22		25		26		25		5	
Flinders University	23	2	27	3	34	20	11	3	6	4	13	2
University of Adelaide	29	8	50	13	57	10	49	16	62	10	35	15
University of South Australia	3	0	3	0	5	1	6	1	8	0	5	3
Total South Australia	55	10	80	16	96	31	66	20	74	14	53	20
	65		96		127		86		88		73	
Curtin University of Technology	14	3	16	3	35	6	41	8	33	9	42	4
Murdoch University	3	1	5	2	4	1	11	0	9	0	15	3
University of Western Australia	19	11	26	8	25	5	20	4	27	3	41	4
Total Western Australia	36	15	47	13	64	12	72	12	69	12	98	11
	51		60		76		84		81		109	
Total Australia	567	142	650	165	732	195	759	162	744	169	712	149
	709		815		927		921		933		861	
Massey University	3	1	6	2	6	2	5	2	4	2	5	0
University of Auckland	102	24	75	9	76	17	83	15	58	11	59	14
University of Canterbury	25	5	19	9	35	7	33	6	30	5	18	7
University of Otago	19	6	20	4	19	4	12	5	17	3	15	3
University of Waikato	11	0	15	0	11	0	11	1	8	1	9	3
Victoria University	21	2	15	2	16	7	12	2	16	3	16	2
Total New Zealand	181	38	150	26	163	37	156	31	133	25	122	29
	219		176		200		187		158		151	

Table 2
Physics Enrolments in Australian & New Zealand Universities 2003 - 2008

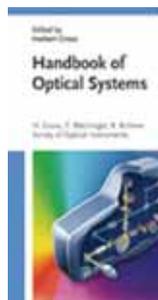
Numbers of Fourth Year Physics Students

Institution	2003		2004		2005		2006		2007		2008	
	M	F	M	F	M	F	M	F	M	F	M	F
Griffith University	3	1	3	1	5	2	7	2	8	0	8	1
James Cook University	0	1	0	0	1	0	3	1	0	1	1	1
Queensland University Technology	2	1	2	3	4	1	4	1	5	1	3	2
Central Queensland University	3	0	3	1	0	0	1	0	1	0	2	0
University of Queensland	8	4	6	3	6	3	7	3	7	3	9	1
University of Southern Queensland	0	0	0	1	1	1	0	0	0	0	0	0
Total Queensland	16	7	14	9	17	7	22	7	21	5	23	5
	23		23		24		29		26		28	
Macquarie University	2	2	6	2	4	0	2	0	3	1	7	1
University of Newcastle	3	0	0	0	3	1	6	1	5	2	1	1
University of New England	0	0	2	0	2	1	2	2	0	0	1	0
University of New South Wales	7	1	12	6	8	5	13	5	16	4	18	2
University of Sydney	13	8	12	5	17	6	13	9	20	5	26	3
University of Technology, Sydney	6	2	4	0	7	0	4	0	2	0	2	0
University of Western Sydney	0	0	1	0	0	0	0	0	0	0	0	0
University of Wollongong	8	3	2	0	3	2	11	5	14	5	5	11
Total New South Wales	39	16	39	13	44	15	51	22	60	17	60	18
	55		52		59		73		77		78	
Australian Defence Force Academy	1	0	1	1	3	0	1	0	2	0	1	0
Australian National Uni - Faculties	13	7	14	3	18	7	24	8	24	8	17	7
Total ACT	14	7	15	4	21	7	25	8	26	8	18	7
	21		19		28		33		34		25	
La Trobe University	5	1	6	1	8	0	3	3	3	0	3	0
Monash University	1	0	9	0	6	3	3	1	4	1	8	2
Royal Melbourne Inst. Technology	8	2	6	0	8	1	9	2	5	3	11	1
Swinburne University	2	0	1	0	0	0	5	2	3	0	3	1
University of Melbourne	23	7	20	2	18	4	18	9	29	12	25	5
Victoria University	3	2	3	0	1	1	0	0	0	0	0	0
Total Victoria	42	12	45	3	41	9	38	17	44	16	50	9
	54		48		50		55		60		59	
University of Tasmania	3	0	1	0	2	2	3	2	6	2	5	2
Total Tasmania	3		1		4		5		8		7	
Flinders University	4	2	4	0	11	0	7	4	4	0	3	1
University of Adelaide	10	2	6	0	12	2	8	1	12	2	22	1
University of South Australia	0	0	0	0	0	0	0	0	1	1	0	0
Total South Australia	14	4	10	0	23	2	15	5	17	3	25	2
	18		10		25		20		20		27	
Curtin University of Technology	2	2	5	2	7	3	14	1	9	2	5	1
Murdoch University	2	0	3	0	2	0	0	0	1	0	3	1
University of Western Australia	11	2	9	2	5	1	5	2	6	1	7	3
Total Western Australia	15	4	17	4	14	5	19	3	16	3	15	5
	19		21		19		22		19		20	
Total Australia	143	50	141	33	162	47	173	64	190	54	196	48
	193		174		209		237		244		244	
Massey University	0	0	0	0	1	0	2	2	0	0	2	0
University of Auckland	54	3	27	6	38	9	20	9	33	7	19	3
University of Canterbury	21	4	26	7	25	9	25	7	21	7	22	8
University of Otago	15	1	10	2	12	3	6	0	7	1	7	1
University of Waikato	15	2	11	0	8	0	2	0	2	0	4	1
Victoria University	4	0	7	2	4	2	10	4	9	3	8	2
Total New Zealand	109	10	81	17	88	23	65	22	72	18	62	15
	119		98		111		87		90		77	

Table 3
Physics Enrolments in Australian & New Zealand Universities 2003 – 2008
Numbers of Postgraduate Physics Students

Institution	2003		2004		2005		2006		2007		2008	
	M	F	M	F	M	F	M	F	M	F	M	F
Griffith University	11	3	10	2	7	3	8	2	7	0	6	1
James Cook University	9	1	12	2	13	2	9	5	8	3	8	3
Queensland Uni of Technology	32	14	30	17	33	19	36	15	34	15	39	18
Central Queensland University	1	0	1	1	2	0	2	0	1	0	0	0
University of Queensland	32	6	36	6	43	5	71	6	66	8	63	6
University of Southern Queensland	6	0	5	0	2	1	6	1	7	2	8	3
Total Queensland	91	24	94	28	100	30	132	29	123	28	124	31
	115		122		130		161		151		155	
Macquarie University	20	5	22	4	27	5	29	9	27	10	33	11
University of Newcastle	14	4	17	4	10	3	11	4	14	5	17	8
University of New England	0	0	1	0	3	0	3	0	3	0	3	0
University of New South Wales	41	14	46	17	33	12	62	18	55	15	48	9
University of Sydney	57	16	69	22	76	26	87	30	89	37	86	27
University of Technology, Sydney	9	6	9	5	8	5	10	2	11	2	11	2
University of Western Sydney	1	0	1	0	1	0	1	0	1	0	0	0
University of Wollongong	21	3	20	4	19	4	24	6	29	8	34	13
Total New South Wales	163	48	185	56	177	55	227	69	229	77	232	70
	211		241		232		296		306		302	
Aust Defence Force Academy	7	1	8	1	4	0	6	1	8	4	3	4
Australian National Uni - Faculties	14	1	20	3	20	3	27	2	26	3	23	2
ANU - Res School of Phys Sciences	57	23	60	25	72	30	77	25	90	22	97	18
Total ACT	78	25	88	29	96	33	110	28	124	29	123	24
	103		117		129		138		153		147	
La Trobe University	11	4	11	4	10	3	15	2	19	2	22	1
Monash University	19	3	21	3	25	1	17	5	18	7	18	8
Royal Melbourne Inst of Technology	35	8	39	13	46	9	45	7	40	9	40	12
Swinburne University	14	3	11	4	11	4	18	4	18	6	17	6
University of Melbourne	54	27	55	24	56	19	63	24	57	18	61	24
Victoria University	6	4	5	3	3	3	4	3	3	2	2	4
Total Victoria	139	49	142	51	151	39	162	45	155	44	160	55
	188		193		190		207		199		215	
University of Tasmania	5	0	6	0	7	1	10	2	11	3	9	4
Total Tasmania	5	0	6	0	8	1	12	2	14	3	13	4
Flinders University	0	0	3	1	7	1	5	3	8	2	6	2
University of Adelaide	46	16	50	19	42	16	50	11	47	7	47	7
University of South Australia	4	0	3	0	2	1	2	1	1	1	1	1
Total South Australia	50	16	56	20	51	18	57	15	56	10	54	10
	66		76		69		72		66		64	
Curtin University of Technology	29	7	23	6	29	5	33	2	40	2	43	4
Murdoch University	9	4	8	3	10	4	7	1	9	2	7	2
University of Western Australia	35	5	29	5	32	4	38	4	42	4	33	4
Total Western Australia	73	16	60	14	71	13	78	7	91	8	83	10
	89		74		84		85		99		93	
Total Australia	599	178	631	198	653	189	776	195	789	199	785	204
	777		829		842		971		988		989	
Massey University	5	1	6	1	6	0	11	1	11	3	12	1
University of Auckland	23	4	28	2	44	6	36	5	20	4	25	5
University of Canterbury	24	17	29	16	33	14	41	13	48	16	36	11
University of Otago	16	5	18	8	13	5	12	2	9	3	14	3
University of Waikato	15	4	18	4	8	2	14	4	3	4	3	2
Victoria University	15	3	18	3	19	2	24	3	23	7	19	7
Total New Zealand	98	34	117	34	123	29	138	28	114	37	109	29
	132		151		152		156		158		138	

Reviews



Prompt Critical

Handbook of Optical Systems Ed. Herbert Gross

Volume 4: Survey of Optical Systems.
Herbert Gross, Fritz Blechinger, Bertram Achtner.
Wiley-VCH, Weinheim 2008
xxviii&1064pp., €298 (hardbound)
ISBN:978-3-527-40380-6

This book is a magnificent blend of the science and art of precision optics and is authored by individuals with impeccable optical design and construction credentials in the best European tradition. I have not seen the previous three books in this six volume series (slated for completion in 2009), but after reviewing this one I am tempted to seek them out.

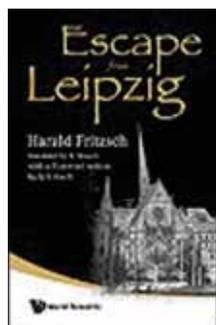
The concept behind this very large volume is to “demonstrate and explain to the reader” about optical systems not just to present a list of recognized, and often patented, optical designs expressed dryly as surface data, materials and spacer dimensions for optical design packages. It succeeds admirably and is beautifully presented.

Gross has enlisted the help of his co-authors to illuminate the text with full colour illustrations and three-colour ray trace and performance data for a myriad of optical designs developed by scientists, technicians and optical enthusiasts over the centuries. That so much has been developed, particularly in the last century, is testament to the usefulness of optical systems and this book is as close as I have come to having an explanation of the whole spectrum of these systems.

I particularly enjoyed the section on the most fascinating optical system, the eye. The discussion on the resolution limits was, like most of this book, concisely stated, clear and informative. The chapter on the amazing trains of optical elements forming lithographic projection systems was interesting and informative particularly on the inclusion of aspherical elements into the latest of these.

Having been mightily impressed with the scope and style of this book, I wonder, in the Australian context, who should buy a copy. Those institutions that offer instruction in, or develop, advanced optics would certainly benefit from this in their library.

John Holdsworth
University of Newcastle



Escape from Leipzig

Harald Fritzsich
World Scientific,
Singapore 2004
xii + 125 pp., US\$
16.00 (paperback)
ISBN-13 978-981-
279-306-5

Highly recommended by a former German Chancellor and no fewer than three Nobel Laureates in Physics, this autobiographical real-life escape thriller needs no further endorsement from me. So I shall be selective and observe that any scientists who had direct experience of the repressive conditions behind the Iron Curtain during the Cold War will encounter little that is new to them.

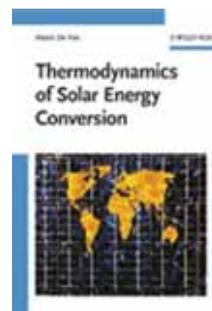
To those others the experiences of physicist Harald Fritzsich (German born and no relation to Lise Meitner's Austrian nephew Otto Frisch) may be a startling revelation of the crushing lack of freedom that exists under contemporary dictatorships, of which several spring to mind.

While still a PhD candidate, Fritzsich and a few close friends discussed in whispers the various ideas for escaping to the West. Overland routes were soon ruled out because of their almost total lack of success. They concluded that by sea success was possible. A reconnaissance trip to the Baltic coast deterred them so they turned their attention south to the Black Sea where they only just managed to complete a hazardous 200-kilometer voyage by canoe from Varna in Bulgaria to Igneada in Turkey – and freedom.

Sixteen years later, after the fall of the Iron Curtain, Fritzsich found himself advising the German government on the assimilation of East Germany. Professors whose chairs were won for political reasons rather than scientific merit were soon demoted.

The book is a sometimes-odd translation from German, The word ‘transparency’ rather than ‘banner’ was a frequent stumble, otherwise meanings were generally clear.

Colin Keay
School of Physics
University of Newcastle



Thermodynamics of Solar Energy Conversion

Wiley –VCH,
Weinheim, 2008
xiii&188pp., £55
(hardbound)
ISBN: 978-3-527-
40841-2

This book is surprisingly easy to follow. I expected a narrative on the fundamental physics of thermodynamic conversion processes to be mathematically intense and conceptually complex. It was neither of these. In fact, one struggles to find a single differential equation in the text. Readers are expected only to have a basic understanding of the laws of thermodynamics.

Alexis De Vos is recognised as an expert in the field of endo-reversible thermodynamics and this subject is a key thread through later chapters. While readers will no doubt be familiar with the reversible Carnot cycle, the author extends the theory to include irreversible heat transfer processes to and from the Carnot cycle.

continued on page 180

Product News

Coherent

Position Sensitive Detectors

Introducing the new Position Sensitive Detectors (PSD's) from New Focus. Unlike conventional quadrant cell detectors, New Focus PSD's display a uniform response to the edge of the sensor. Coupled with a wide spectral response, high speed USB and conventional analogue outputs, they allow for large deviations in laser beam position to be monitored with unprecedented ease, making realignment of free-space beam configurations simple.

- Photodetector size ranging from 4mm x 4mm to 12mm x 12mm
- Wavelength range: 320nm - 1100nm
- Digital (USB2.0) and analogue (SMB) outputs
- Continuous wave (CW) saturation power: 5mW
- Analogue output signal: X, Y, SUM or X/SUM, Y/SUM, SUM



For more information, please contact
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sales@coherent.com.au
www.coherent.com.au

Hysitron's new TEM Picoindenter - exploring new frontiers in nanomechanical testing

The PI 95 TEM PicoIndenter™ from Hysitron, Inc. is the first full-fledged depth-sensing indenter capable of direct-observation nanomechanical testing in a transmission electron microscope (TEM). This pioneering in situ instrument is specifically designed to overcome the numerous configurational and environmental challenges presented by TEMs, allowing a quantitative force-displacement curve to be time correlated to the corresponding TEM movie of the stress-induced deformation process. This coupling of high-resolution techniques enables a researcher to witness, for example, the microscopic origin of a measured force or displacement transient.

The key enabling technology of the PI 95 TEM PicoIndenter™ is its novel miniature transducer. With this newly-developed transducer, in situ force-displacement curves can be acquired in a highly accurate depth-sensing manner, instead of relying on an inherently troublesome series-loading, spring-deflection-force scheme. Furthermore, substantially larger forces can be realised without suffering a force sensitivity penalty.

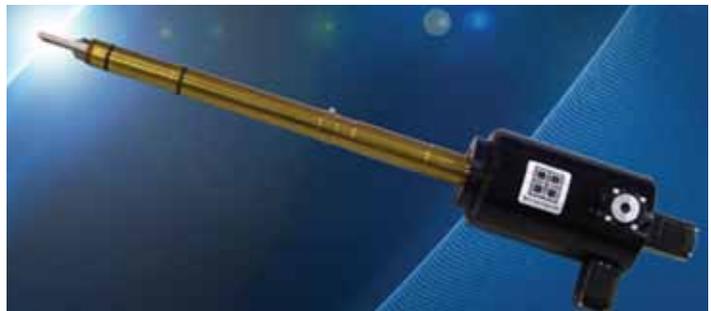
The PI 95 TEM PicoIndenter™ provides;

- Fully fledged depth-sensing indentation
- Time correlated force vs. displacement data with TEM imaging
- Low load noise floor - 10's nano Newtons
- Direct observation of nanomechanical processes
- Viewing of force or displacement transient events in real time
- Newly developed miniature electrostatic force transducer
- High speed digital controller
- Cost effective upgrade for TEM's

Applications include:

- Visualisation of grain boundary changes and the onset of plasticity and deformation in real time
- Viewing and measuring the fracture toughness of hollow nanospheres
- Viewing and measuring the compression of helical nanocoils
- Viewing and measuring the bending force of single carbon nanowires

For more information, please contact
Chrisitan Gow at Coherent Scientific
sales@coherent.com.au
www.coherent.com.au



Warsash Scientific

Spectrum Detector's Delta Radiometers/Joulemeters expand into the Near Infrared



Warsash Scientific is pleased to announce a near-IR addition to the revolutionary Delta Radiometer / Joulemeter series from Spectrum Detector Inc. The Delta NIR Joulemeter provides near-IR spectral response from 0.9 to 1.7 μm , while also offering numerous performance advantages unique to the Delta Series of joulemeters and radiometers.

Compact, flexible and economical, the Delta Series' design is unlike any other on the market: the user simply plugs a Delta probe into an analog power module (APM) to mate with oscilloscopes and lock-in amplifiers,

or plugs the probe into a digital USB-based electronic module (DPM) to create a complete PC based energy meter. Powerful LabView software controls range, wavelength, trigger level, graphic displays and much more.

Measurement performance rivals that of advanced readout-based meters; the Delta NIR Joulemeter features germanium or InGaAs detectors, 10 fJ sensitivity, high voltage responsivity (10KV/J) and high rep-rate capability. It is ideally suited for measuring laser pulse energy from 1 to 40,000 pps, and measuring pulse energy of eye-safe lasers.

It is easy to tailor the Delta for a specific measurement need. A full range of smart Delta probes is plug-and-play compatible with the analogue and digital modules. Probes include Si, Ge and InGaAs photodiodes or pyroelectric detectors, covering the spectrum from DUV to FAR IR and even the THz region. Each probe includes an EEPROM that identifies the type of sensor, its voltage response and wavelength correction factors for the digital electronics. An SM1 threaded front bezel makes it easy to add filters, apertures, lenses, optical holders and more.

Design flexibility is another hallmark of the Delta Series. The low-profile probes and compact power modules are optimal for on-board applications such as laser diagnostics or control. OEM versions include bare-board configurations complete with shielded cables that plug directly into the principal system's processing board. The low-profile probes are ideal for performing measurements in tight spaces.

"The Delta Series gives users the choice of multiple joulemeters and radiometers for less than the price of a single readout-based system," said Don Dooley, president of Spectrum Detector. "Flexible and affordable, the Delta Series is the perfect fit: it fits the performance requirements, the physical requirements, the budget requirements, even future requirements."

Further information on this and other Spectrum Detector Inc instrumentation available from:
Warsash Scientific Pty Ltd
Tel: +61 2 9319 0122
Fax: +61 2 9318 2192
sales@warsash.com.au
www.warsash.com.au

Increased Output Power of Diode Pumped Solid State (DPSS) Lasers

Due to the need for increased processing speeds for laser based industrial processing applications, Photonics Industries International has now increased the power and pulse repetition rate of its DS Series diode pumped solid state lasers to 30W at 300kHz at 1064nm. PI's enhanced DS Series diode pumped solid state lasers are available from Warsash Scientific.



DS series Diode Pumped Solid State Lasers

Higher power at higher pulse repetition rates gives higher processing speed. While increased pulse energy is typically required to prove in the technical feasibility of the laser based material processing, increased processing speed is generally required to prove in the laser process over mechanical based material process.

Photonics Industries new DS20HE-1064 Series laser achieves over 1mJ pulse energies in IR (@1064nm) operating at a rep rate up to 300kHz with pulse widths ~130 ns while still maintaining TEM00 mode quality. This higher power laser is also available in green (532nm), UV (355nm) or DUV (266nm) for a variety of material processing applications.

Further information on this and other Laser solutions available from:
Warsash Scientific Pty Ltd
Tel: +61 2 9319 0122
Fax: +61 2 9318 2192
sales@warsash.com.au
www.warsash.com.au

New Cobolt 594nm solid state laser available from Warsash Scientific

Warsash Scientific is pleased to announce the release of the compact Cobolt Mambo™ to further expand Cobolt's renowned product portfolio of compact visible lasers into the orange. The Cobolt Mambo™ is a continuous-wave solid-state lasers operating at a fixed wavelength 594nm, with an output power of 25 mW and is perfectly suited for fluorescence analysis applications such as confocal microscopy and flow cytometry.

As part of Cobolt's product-line for high-performance DPSS lasers in the visible, the Cobolt Mambo™ is a single longitudinal mode laser with very low noise, narrow spectral line width and exceptionally high beam quality.

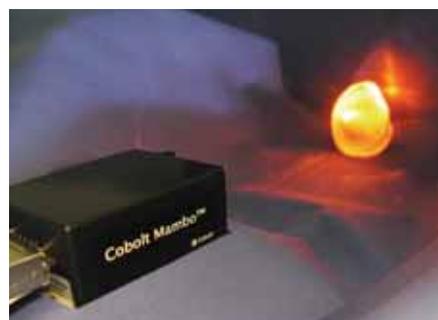
The Cobolt lasers are based on proprietary PPKTP frequency conversion technology and built on an ultra-robust platform into a hermetically sealed package. They feature low noise (<0.3 % rms) and excellent beam quality ($M^2 < 1.1$) over a wide temperature range (10 to 40 °C) and show outstanding resistance to thermal and mechanical shocks. Due to the high efficiency, the full system typically consumes less than 25 W of electrical power.

The Cobolt Mambo™ laser provides a compact solid-state and higher power alternative to HeNe lasers, which opens up a new range of fluorescence applications, in particular for the excitation of Alex Fluor 594, Texas Red and the new very bright gene expression proteins mCherry & mKate.

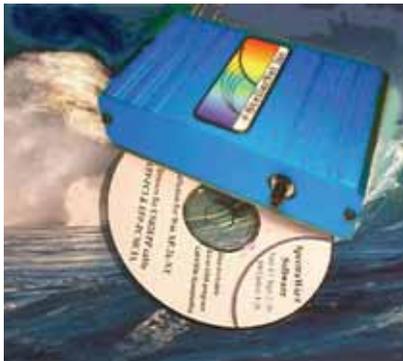
Cobolt now offers a complete range of high performance DPSS lasers to the fluorescence based bioanalytical industry: 473 nm, 491 nm, 515nm, 532 nm, 561 nm, and 594 nm lasers are currently available at output powers from 10 to 300 mW.

The laser controller is available both in a CDRH version and as an ultra-compact remotely controllable OEM model. It is built on a robust platform with mounting holes for convenient installation and optimum heat dissipation. It is remotely controllable for operation and monitoring of the laser system via digital (RS-232) or analogue interfaces.

Further information on this and laser systems available from:
Warsash Scientific Pty Ltd
Tel: +61 2 9319 0122
Fax: +61 2 9318 2192
sales@warsash.com.au
www.warsash.com.au



New miniature BLUE-Wave Spectrometers for UV-VIS-NIR from Warsash Scientific



Warsash Scientific is pleased to present StellarNet's new range of miniature BLUE-Wave UV-VIS-NIR Spectrometers. 15 models provide configurations for a variety of spectral ranges and resolutions with dispersive optics imaging to a 2048 element CCD detector array. The instruments have SMA-905 fibre optic input with a high speed USB-2 computer interface. An integrated 16-bit digitizer and spectral memory produce a signal to noise of 1000:1 with fast conversion times down to 1ms.

The BLUE-Wave is exceptionally robust utilizing a vibration tolerant modular design with no moving parts or sockets for extreme reliability. Powered by USB, up to 8 instruments can be run simultaneously via a USB hub. The instruments can also be externally triggered for demanding applications such as LIBS. Its small size and weight is perfect for portable and OEM applications.

Measurement applications include spectroradiometry for emission wavelength monitoring & characterization of LEDs and tuneable lasers, chemical analysis via absorbance & fluorescence, colour QC via reflectance, thin film thickness measurements, transmission analysis of optics, and fibre optic sensing.

Further information on this and other spectrometer instrumentation available from:

Warsash Scientific Pty Ltd
Tel: +61 2 9319 0122
Fax: +61 2 9318 2192
sales@warsash.com.au
www.warsash.com.au

**Lastek
Aerotech's Ensemble™ Stand-Alone Multi-Axis Motion Controller wins award!**

Taking out this year's Semiconductor International Editor Choice Award for Best Product is the Ensemble™ Control platform from Aerotech.

The Ensemble™ is Aerotech's next-generation, multi-axis controller for moderate- to high-performance applications with high speed communication through 10/100 Base T Ethernet or USB interfaces. The Ensemble™ can control any Aerotech brushless, brush, or stepper motors or stages in any combination, and both PWM and linear drives are available.

It offers easy to use, affordable multi-axis motion programming for laboratory experimentation, production testing, or advanced OEM automated manufacturing systems.

The versatile Ensemble™ offers three methods for stand-alone, multi-axis control.

Option 1: Use the Ensemble™ Epaq with integrated drives to control up to six axes for desktop or rack-mount applications.

Option 2: Use a distributed network of panel-mounted Ensemble™ CP/MP/CL drives to provide up to ten axes of synchronized motion.

Option 3: Use the Ensemble™ Epaq and add three Ensemble™ CP/MP/CL panel-mounted external drives for up to nine axes of motion control.

Features:

- Up to 10 axes of coordinated motion
- Multiple 10-axis systems can be controlled by a single PC via Ethernet or USB

- Controller architecture capable of coordinating motion of up to five independent tasks
- Capable of driving and controlling linear or rotary brushless, DC brush servo, and micro-stepping motors
- Complete motion capabilities include: point-to-point, linear and circular interpolation, electronic gearing, velocity profiling
- Program in AeroBASIC™ with the IDE, Microsoft .NET including C#, VB.NET®, Managed C++, or LabVIEW® over Ethernet or USB from Windows® 2000 or Windows® XP
- Remote ASCII interface provided for Windows® or non-Windows® programs (including Linux) to command the Epaq through standard Ethernet, RS-232 port, and optional IEEE-488
- Fully compatible with EPICS set of software tools and applications, making Ensemble ideal for use in synchrotron and general laboratory facilities
- Advanced Windows®-based remote diagnostics, tuning, and programming interface software
- Axis jogging/control with optional joystick
- Allen-Bradley interface provides full integration with the Ensemble; program the Ensemble directly from RSLogix™ 5000

For more information contact Lastek at:
Lastek Pty Ld
Adelaide University - Thebarton Campus
10 Reid St, Thebarton, SA
Toll Free: Australia 1800 882 215 ; NZ 0800 441 005
T: +61 8 8443 8668 ; F: +61 8 8443 8427
email: sales@lastek.com.au
web: www.lastek.com.au

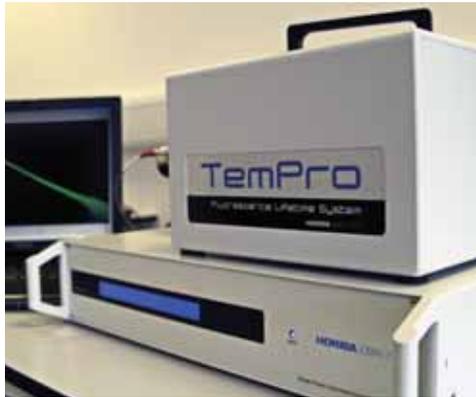


New TemPro from HORIBA Jobin Yvon
 HORIBA Jobin Yvon announces the new TemPro, a low-cost filter-based TCSPC lifetime spectrofluorometer.

The TemPro lifetime system is so affordable that any lab can now exploit the power of fluorescence dynamics using time-correlated single photon counting (TCSPC), the most sensitive method for fluorescence measurements. HORIBA Jobin Yvon offers this most powerful of time-domain techniques in a compact desktop instrument that can measure lifetimes ranging from picoseconds to seconds. The TemPro takes advantage of interchangeable pulsed laser-diode and LED light-sources covering discrete emission wavelengths from 255 nm to the near-IR.

The TemPro has many advantages:

- Significantly cheaper than other instruments
- Full lifetime capability from 100 ps to 1 second
- Fast, reliable USB 2.0 interface for easy data-transfer to your PC
- New DataHub electronics
- Controlled by included DataStation software



- Right-angle cuvette holder with quick-connect tube fittings for temperature control via an external water-bath (water-bath not included)
- Expand the optical system easily into a monochromator-based system capable of Time-Resolved Emission Spectra (TRES)
- Excitation with all existing NanoLEDs (for picosecond to microsecond lifetimes) and SpectraLEDs (for microsecond and longer lifetimes) from the UV through near-IR
- Detector response is 185–650 nm
- Detector is protected via high-voltage cut-off when the sample chamber's lid is removed

- Analyze the data with included DAS6 software
- May be upgraded to include monochromators, motorized or manual polarizers, digital temperature-sensing cuvette-holder, front-face sample-holder, and extended detection to 850 nm

Value, power, and compactness are the hallmarks of TemPro, a product perfect for basic research and analytical measurements. HORIBA Jobin Yvon backs the TemPro with nearly 200 years of sales, service, and applications expertise in optical instrumentation.

The TemPro is also compatible with most FluoroCube accessories.

For more information contact Lastek at:
 Lastek Pty Ltd
 Adelaide University
 10 Reid St, Thebarton, SA
 Aus 1800 882 215 ; NZ 0800 441 005
 T: +61 8 8443 8668 ; F: +61 8 8443 8427
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Conferences

November 17 - 20

14th International Conference on Thin Films

Belgium, Ghent

www.ictf14.ugent.be/

Nov 30 – Dec 5

18th National AIP Physics Congress

Adelaide, South Australia

www.aip.org.au

December 1- 5

XVI Conference on Non-equilibrium Statistical Mechanics & Nonlinear Physics (MEDYFINOL'08)

Uruguay

medyfinol08.fisica.edu.uy

December 12 - 13

2nd International Conference on Science and Technology (ICSTIE'08)

Penang, Malaysia

www.icstie.com

2009

January 21 - 24

Nanobiophysics & Chemistry

Bolans Village, Antigua and Barbuda

<http://www.zingconferences.com/index.cfm?page=conference&intConferenceID=44&type=conference>

February 11 - 13

38th National Seminar on Crystallography

Mysore, Karnakata, India

<http://38nsc2009.synthasite.com/abstracts.php>

March 25 - 30

ISF Research Workshop on Random Matrices and Integrability: From Theory to Applications

Yad Hashmona (Judean Hills), Israel

<http://www.hit.ac.il/staff/kanzieper/yad8>

June 29 – July 5

The 6th International Conference on Non-Accelerator New Physics (NANP'09)

Dubna, Moscow region, Russian Federation

nuweb.jinr.ru/~nanp

September 23

ICNEP 2009 - International Conference on Nanoscience, Electronics and Photonics

Vancouver, Other

<http://www.waset.org/wcset09/vancouver/icnep/>

September 7 - 11

9th International DYMAT Conference on the Mechanical and Physical Behaviour of Materials under Dynamic Loading

Brussels, Belgium

www.dymat2009.org

Reviews continued from page 175

Such irreversible cycles are classified as Curzon-Ahlborn cycles (linear heat transfer processes) and the Stefan-Boltzmann cycles (non-linear heat transfer processes). The book uses this thread to describe fundamental limits to solar conversion processes by representing them as endo-reversible cycles. Wind energy, photothermal, photovoltaic, hybrid PV/T, solar concentrators, photochemical and photosynthetic solar processes are all covered. Most chapters conclude with real-world examples, learning exercises, a conclusion and references.

As an engineer, I admit to a preference to dealing in exergy and exergetic efficiency. I also found the material on solar concentrators to be brief. These are minor criticisms of a very well compiled book. Indeed the author acknowledges that the book is not intended to be comprehensive in scope but it does provide a framework upon which one might conduct specific analyses.

Molecular Dynamics continued from page 163

For further reading

Understanding Molecular Simulation, D Frenkel & B Smit, Academic Press.

Computer Simulation of Liquids, MP Allen & DJ Tildesley, Oxford University Press.

Bonding and Structure of Molecules and Solids, D Pettifor, Oxford University Press.

Feynman Lectures in Physics, Vol. I, Sec. 9.6.

R Car and M Parrinello, Phys. Rev. Lett. 55, 2471 (1985).

This is not the dry theoretical thermodynamics text I might have expected. The author writes in a style that clearly demonstrates empathy with his reader and the narrative is very well structured. I would suggest that advanced students of physics and engineering would find this text stimulating.

Dr Mike Dennis

Department of Engineering
The Australian National University

Errata

The review by Martijn de Sterke of; **Wave Propagation. From Electrons to Photonic Crystals and Left-Handed Materials** appearing in the July-August issue had a symbol conversion error where the intended $e^{i\Omega t}$ factors emerged as e^{int} . Apologies are extended.

Online information and movies

Molecular Dynamics - Wikipedia;
http://en.wikipedia.org/wiki/Molecular_dynamics

Introduction to MD Simulation;
<http://www.fz-juelich.de/nic-series/volume23/allen.pdf>

Simulations of the villin headpiece;
<http://www.stanford.edu/group/pandegroup/folding/villin/>

Kai Nordlund. Movies of ion impact;
<http://beam.acclab.helsinki.fi/~knordlun/animations.html>

Lau et al., Phys. Rev. Lett. 100, 176101 (2008).
<http://link.aps.org/abstract/PRL/v100/e176101>

New Agilis Piezo Driven Components

Newport's new piezo motor driven optical components take a completely new design approach to the adjustments needed for many laser setups. Agilis Mirror Mounts, Linear Stages and Rotary Stages provide the ultra-high adjustment sensitivity and convenient remote operation of a motorized component at the price and size of a manual mount or stage!

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Agilis Mirror Mount

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Agilis Rotary Stage

A\$854



Agilis USB Controller

A\$399



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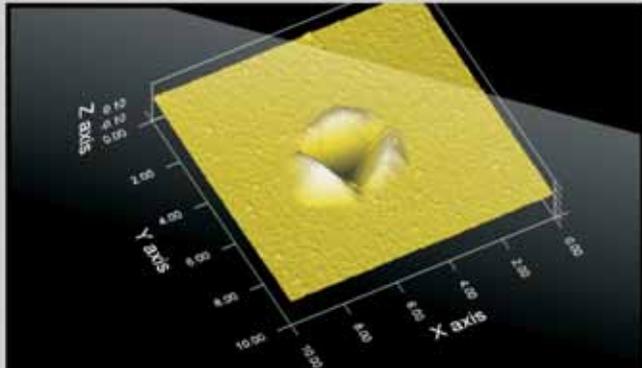
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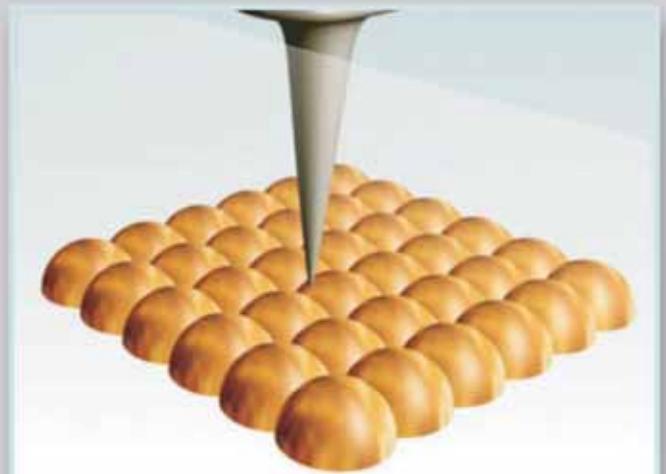
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Nano & Micro Indentation

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Surface metrology

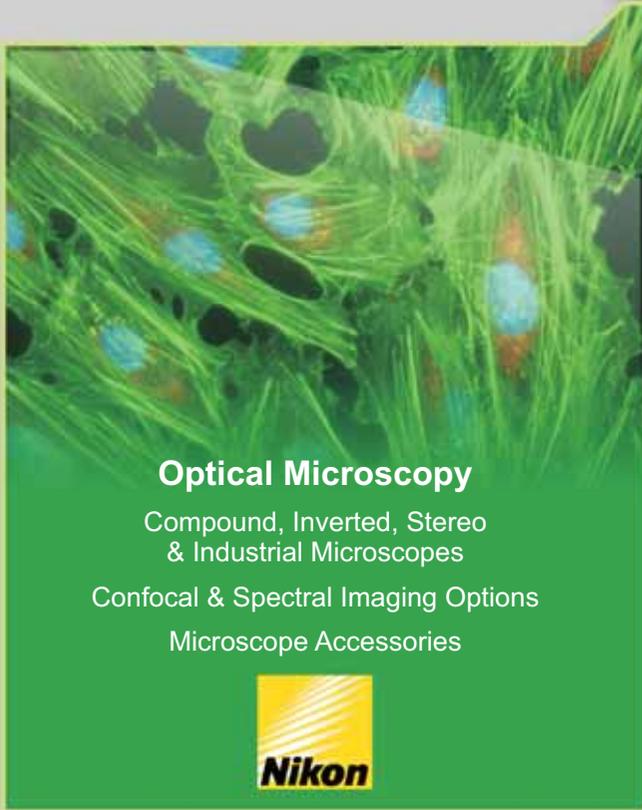
Scanning Probe Microscopes (SPM's)

Scanning Near-field Optical
Microscopes (SNOM's)

High Vacuum SPM's



Nanotechnology Division of Intel for Nanotechnology

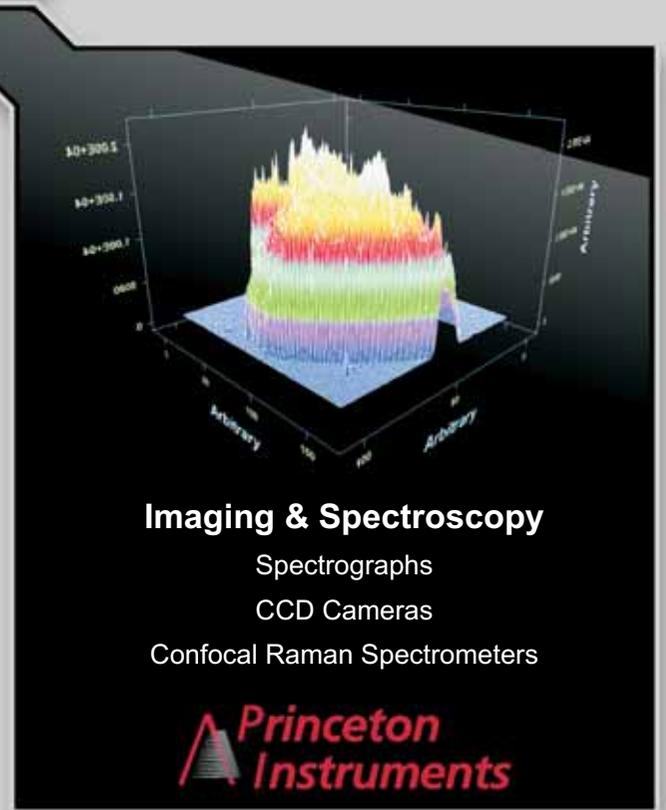


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