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PRESIDENT'S COLUMN

First, a brief update on AIP matters. A revised version of the AIP constitution has been forwarded to our Solicitors for comment before being presented to the AGM/Council meeting scheduled for February 2004. (Details of the AGM and Council meeting are provided inside.) The primary reason for the revision is to simplify the grades of membership, however, we have also taken the opportunity to remove some of the anachronistic clauses and phrases contained in the current document. It is proposed that the new grades of membership be: Associate, Member, Fellow and Honorary Fellow. In this structure students will join as Associates and will become eligible for Membership upon graduation. This has the advantage of simplifying the joining process as no academic transcripts or other professional qualifications are required for Associates. The former Graduate grade will be absorbed into the Member grade but with a scaled level of fees over the first few years to ease the transition. The amended constitution will be posted on the AIP website for comment as soon as it is approved by the solicitor (and at least 21 days prior to the AGM as required). In other news, we have produced and distributed new AIP posters, brochures and application forms to promote the AIP and encourage membership. Keep your eyes open for the new look. Those members taking advantage of the IOF reciprocal membership deal will be aware that the negotiated fee for 2004 remained at the 2003 level. This continues to be extremely good value.

October was a busy month for meetings and lobbying, with an Executive Meeting held at ANU on October 13, a Physics Heads-of-Department (HOD's) meeting held at the ANU on the morning of October 14, and the annual FASTS Science meets Parliament days held on October 14 and 15. The HOD's meeting, which was facilitated by the AIP, was well attended and addressed issues of key importance. A press release was subsequently prepared to highlight a key concern of the HOD's, namely the plight of secondary physics teaching and the need for a national curriculum. It began: "At a meeting in Canberra this month, Heads of Physics from 18 of the country's top universities expressed concern at the watering-down of the high school physics syllabus across Australia. Of particular concern is the loss of clarity in the goals of the new NSW HSC syllabus", and later noted: "The Australian Heads of Physics welcome the announcement by Dr Brendan Nelson of moves to establish a nationally accepted core curriculum. The Heads express a desire to work with DEST and the Australian Institute of Physics to create a reference physics curriculum, which will be anchored in contemporary international standards. The AIP welcomes this comment and looks forward to taking a leading role in the initiative. Science meets Parliament (SmP) was also a great success this year, with Physics being well represented by young and 'mature' members alike. To encourage participation the AIP funded the attendance of two members from each State and encouraged Branches to include at least one young (under 40) member. Feedback from those who attended was extremely positive, although it must be said that the comments about individual politicians varied considerably!

One of the greatest rewards of the AIP Presidency is acknowledging the achievements of outstanding individuals. It is therefore a pleasure, on behalf of the Australian Physics community, to congratulate Prof. Gerard Milburn on being awarded the 2003 Walter Boys Medal for his work on quantum information theory, and to congratulate Prof. John Prescott on being awarded an Outstanding Service to Physics in Australia Award, partly for his role in collecting and reporting physics recruitment statistics for the AIP over the past 25 years.

Finally, as indicated in my recent letter to members, the year 2005 has been designated the World Year of Physics, and will likely be designated the International Year of Physics, to celebrate the centenary of Einstein's famous 1905 paper entitled Zur Elektrodynamik bewegter Körper, which laid the foundations of special relativity. I have also recently been reminded that this was also the year that Einstein published his seminal papers on Brownian motion and the photoelectric effect, for the latter of which he received the Nobel Prize. All-in-all a pretty good year! (However, I do wonder how Einstein would be rated today based on only three papers and in journals of questionable impact factor! Perhaps the citation rates make up for it.) Clearly 2005 will be a great opportunity to showcase physics and its contribution to society. As a consequence, the AIP will be establishing a working party to coordinate high-profile events during 2005, including the AIP Congress scheduled for February of this year. We would welcome suggestions for events and activities as well as the names of people or organisations that could assist with their planning and execution.

Merry Christmas.

Rob Elliman
A question of papers

I read the article by Dr K. Scott Butcher with interest (horror may be the better word). I will not comment on the factual matters except to ask if it was refereed, which it should have been, before publication.

My major question is in section 11. Dr Butcher states that, while at university, he published 8 journal papers per year. This is a huge number, particularly as he must have done some teaching. Were these all refereed? Could the Government score be lower because the manuscripts needed to be approved by the division chief before submission?

The "golden years" of physics ended in the 50's, however the subject is not dead. The future should be examined by the AIP, but the questionnaire issued by Dr Butcher should not be the basis.

Yours faithfully,

TM Sabine
Emeritus Professor,
University of Technology, Sydney

Responses

Regarding the question about my eight journal publications, Dr Arthur Prior asked a similar question and I responded to him by supplying the reprints of the eight publications that I made last year. All of these were published in well-respected, refereed journals and proceedings (all DEST Cl and El publications). You can thus confirm my assertion with regards the number of my publications last year by speaking to him or, if you like, I can send a set of reprints to you as well.

As the response from the science culture questionnaire is indicating, many physicists work extremely hard when in the right work environment, and I am no exception. However I will say that the area of my specialisation allows for a greater number of papers than in many other areas, that's just the nature of my field. That I couldn't publish at the same rate in the government establishment was, in part, due to things like trying to get approval from busy division heads who were unable to delegate and simply didn't have time. A host of other redundant bureaucratic processes were in place to slow such things. To a larger degree it was simply that, in that establishment, science was a secondary concern to a high level of paper shuffling, so even a lowly researcher like myself had very little time for research.

In regard to the question as to whether the article in the Physicist was refereed, no, it was not a research paper (and it won't appear in the DEST list either) and was not portrayed as such. As mentioned in the article it is part of an information gathering exercise, it is my experiences only and in the article I asked for other people to share their experiences to see if we could achieve a wider picture than just my views.

However, I did give the AIP executive and my department head copies of the questionnaire and the "June/July Physicist article" for comment before proceeding, and I will say that they have been very supportive.

I also thought I should respond to Matthew Fowell's "dangers of generalisation" letter in the August/September 2003 issue of The Physicist.

I was actually very happy to see his response and the response of others to the questionnaire. In fact the main purpose of doing the questionnaire was to try and see how things are in Physics across the board in Australia. I’m happy to report that Matthew was right, there do indeed appear to be areas in the DSTO and CSIRO where things are going well, and unfortunately there appear to be areas in many universities where things aren’t going very well at all. Perhaps Matthew himself was a little guilty of generalising his own perceptions however, as there are also areas in the CSIRO and DSTO where there is considerable discontent - the overall picture is a patchwork.

[See Scott's follow-up article in this issue – Ed.]

Perhaps most illuminating to me was a conversation I had with a DSTO researcher at the FASTS Science meets Parliament day a couple of weeks back. He was telling me that the section of DSTO he works in now is terrific; the government is particularly interested in their area of work for security reasons and they're being left to get on with the job in a very supportive and energetic environment. But he also told me that the sections of the DSTO he previously worked in had many of the characteristics described in the “culture of no” article that I wrote for the June/July 2003 edition of The Physicist. To me its somewhat disconcerting that there can be areas of such disparity in the one organisation. However, thinking back I had also seen this in the government labs I was in.

Mind you I think it’s a mistake to ignore such disparity. I know that Matthew Fowell came from the University of New England before joining the DSTO, and that the Physics department there was virtually closed down (and interestingly enough is now being somewhat revitalised – perhaps physics can’t be done without entirely). At the same time that New England was being threatened, two other NSW physics departments were under similar threat. They were strongly supported by the AIP NSW branch of the time and by all accounts that support made a difference, certain UTS staff (including the then head of department) swear to this day that the then president of the NSW branch was instrumental in saving physics at UTS. That’s just one example. If we act collectively as a discipline we can make a big difference to the management and environment of physics within Australia.

Scott Butcher
AIP Science Policy Convenor
The discovery of our closest galaxy

Sydney University astronomers are part of an international team of which has discovered a new galaxy colliding with our own Milky Way.

The Canis Major dwarf galaxy, named after the constellation it is found in, lay hidden until now in the dense disk of the Milky Way. Its discovery was made possible by a new survey of the sky in infrared light, which has allowed astronomers to see through the dust is the disk of the Milky Way that obscures our view to distant stars.

Teams of astronomers from France, Italy, England and Sydney University's Institute of Astronomy pinpointed the new dwarf galaxy by detecting its M-giant stars, which are cool red stars that shine especially brightly in infrared light. They then used the rare M-giant stars as beacons to trace out the numerous other stars that are too faint for us to see. These M-giant stars are particularly useful as we can measure their distances, and so map out the three-dimensional structure of distant regions of the Milky Way disk.

The discovery of the closest galaxy to our own shows that the disk of the Milky Way was built up by absorbing its own satellite galaxies. Astronomers currently believe that large galaxies like the Milky Way were built up to their present majestic proportions by consuming their smaller galactic neighbours. However, until now it was not appreciated that even the disks of galaxies can grow in this fashion. On galactic scales, the Canis Major dwarf galaxy is a lightweight, weighing in at only about one billion Suns. The smaller galaxy is pushed and pulled by the colossal gravity of our Milky Way, which has been progressively stealing its stars. It is unlikely that it will be able to hold itself together much longer.

Numerical simulations show that this accretion has been adding and will continue to add to the stars in the disk of the Milky Way. The remnants of the galaxy collision form a ring around the disk of the Milky Way. The Canis Major dwarf galaxy may have added up to 1 per cent more mass to our Galaxy, said Dr Geraint Lewis of the University of Sydney. This is also an important discovery because it highlights that the Milky Way is not in its middle age and it is still forming. It seems that the cannibalised Canis Major galaxy does not only contribute stars to the outer reaches of the Milky Way disk, the pulled-out stream of stars may also pass close to the Sun. These types of interactions could form some of the exquisite detail of our galaxy that we see today.

Sydney University Press Release

Solar Eclipse from Dome C Antarctica

On 24th November a total eclipse of the sun occurred over regions of the Antarctic continent.

Professor John Storey, head of physics at UNSW, was at Dome C, 1600 kilometres from the South Pole. He pointed a camera sunwards and beamed pictures of the eclipse back to the school of physics website.

A narrow region of east Antarctica and the Southern Ocean lay in the path of totality and experienced a total eclipse. There are only a few Antarctic stations within this region: bases over the rest of the Antarctic continent experienced a partial eclipse.

The French Italian Dome Concordia station (Dome C) is one of only a few stations on the high Antarctic plateau. It is located at 75 degrees South latitude, 175 degrees East longitude and is 3260 m above sea level. An 85% partial eclipse was visible from Dome C.

Professor Storey and Dr Anna Moore, from the Anglo-Australian Observatory, were on a three week visit to the Dome to perform maintenance on the Automated Astrophysical Site Testing Invincible Observatory (AASTINO) - a remote laboratory set up in January to measure the atmospheric characteristics of the Dome C site relevant to astronomy. Their progress can be followed via the daily Antarctic diaries.

UNSW Media Release

Do Microfluid Pumps Give Humans Their Sensitive Hearing?

New images of movements inside the cochlea, the part of the inner ear responsible for auditory function, suggest that the incredible sensitivity of mammalian hearing may be the result of hair cells that act as electromechanical fluid pumps.

Arranged in a spiral structure known as the organ of Corti, the cochlea's outer hair cells exhibit voltage changes in response to sound, and change their length in response to an electrical voltage. At the Acoustical Society of America in Austin earlier this month, researchers (David Mountain, Boston University, and Domenica Karavitaki, now at Harvard Medical School) presented visual evidence of contracting hair cells pushing fluid back and forth. The fluid traveled through a tiny channel in the sensory organ known as the tunnel of Corti. According to theoretical calculations by Mountain and colleagues, hearing sensitivity is increased 100-fold if this fluid flow is properly synchronized with sound-induced motions in the cochlea. To image small but very rapid vibrations in the cochlea, Karavitaki used stroboscopic illumination flashing at rates 10,000 times a second to "freeze" the motion of the cells. This visual evidence of outer hair cells acting as electromechanical fluid pumps supports the researchers' theory of cochlear function, which states that an increase in hearing sensitivity cannot take place without fluid flow through the tunnel of Corti. Among all vertebrates, only mammals have a tunnel of Corti, and only mammal ears have hair cells that change their lengths in response to an electrical voltage. (Paper 4pAABa4 at meeting; lay-language paper with diagrams and movies)

Physics News

Solar-powered solution filters through

A solar-powered water filtration system, jointly developed by UNSW's Dr Bryce Richards and Dr Andrea Schaffer of the University of Wollongong, has won second prize at the prestigious Energy Globe Awards competition.

The Reverse Osmosis Solar Installation, known as ROSI, could alleviate the scarcity of drinking water in remote communities and has taken second place in the water category of the sustainable energy competition, held in Austria last week. The Energy Globe Awards are given to projects from all over the world that contribute to the protection of the planet and its ecosystems. Dr Richards, from the Centre for Photovoltaic Engineering, originally started work on ROSI in his spare time during his PhD.

ROSI is a desalination system that could produce clean drinking water in a variety of remote locations in Australia, using solar energy without the addition of chemicals or producing pollution. Availability of drinking water in these remote communities is often dependent on external supplies once rainwater sources are exhausted. The current ROSI system is designed to remove pathogens, poisons, salt and other contaminants from brackish ground water.

"There are about a billion people without access to clean water worldwide," Dr Richards said. "Hopefully, this research will enable us to bring help to the people who need it and whose lives it will change, whether that is in remote areas of Australia or in third world nations."

The Energy Globe Awards attract more than 1,000 entrants each year from 95 countries. The judging panel was made up of representatives from the Electrical Power Research Institutes in the US, the European Renewable Energy Council, the Club of Rome and the Sustainable Energy Authority of Victoria.

UNSW Media Release
Yes, according to an experimental and theoretical analysis performed by researchers at Monash University in Australia (David May and Joseph Monaghan). The ocean floor contains vast quantities of methane gas hydrates - ice-like crystals of methane surrounded by cages of water molecules. If disturbed, these methane gas hydrates can erupt from the floor and rise to the surface as gas bubbles, some of which can be very large.

Cupious amounts of methane hydrates exist in the North Sea, which lies between the United Kingdom and continental Europe. At a large eruption site in the North Sea known as the Witches Hole off the coast of Aberdeen, a sonar survey recently discovered the presence of a sunken vessel, but the cause of the wreck remains undetermined. Simple experiments have previously shown that many small bubbles rising to the surface could sink a cylinder of water (and conceivably a ship), by causing a loss of buoyancy (Denardo et al., American Journal of Physics, October 2001). But could a single large gas bubble do the trick? The Monash researchers investigated this possibility in a simple, roughly two-dimensional system. Trapping water between a pair of vertical glass plates, and launching single gas bubbles from the bottom, they used a video camera to observe a single large bubble's effect on a small piece of acrylic shaped like the hull of a boat.

Along with numerical simulations of this scenario, the experiments showed that the bubble could sink the ship, if the bubble's radius was comparable to or greater than the ship's hull. Sinking would occur because a mound of water formed above the bubble as it approached the surface. As the bubble reached the surface, it would temporarily lift the ship. However, water in the mound would then flow off the sides of the bubble, forming deep troughs at either side, and the water flow would carry the boat to one of the troughs. In addition, the eventual rupture of the bubble would create high-velocity jets of fluid that moved into the troughs, creating vortices that further pulled down the boat. The researchers say that their numerical simulations could test other scenarios, including those involving multiple large bubbles, more realistic boats, and ultimately a full three-dimensional simulation. (American Journal of Physics, September 2003).

Physics News

New conductor stands the heat

Researchers in the US have discovered a metallic alloy that does not expand or contract when heated and also conducts electricity at the same time. The material could have applications in components that encounter large temperature fluctuations, such as motors and actuators, and also in space (J Salvador et al. 2003 Nature 425 702).

Most materials expand when heated, although a small number contract instead. If combined, these two types of material can form a composite that does not change in size as the temperature is changed. These are useful because they can withstand rapid variations in temperature.

Now Mercuri Kapetanidis and colleagues at Michigan State University have discovered that a non-composite material - an alloy of ytterbium, gallium and germanium - can also exhibit zero-expansion behaviour. Moreover, the new compound conducts electricity, while previous zero-expansion materials were insulators. Furthermore, the effect is observed over a wide temperature range - between 100 and 400 Kelvin.

Kapetanidis and co-workers speculate that the sample cools, delocalized electrons in the valence band associated with the gallium atoms become localized on ytterbium atoms, which expand as they accept the electrons. The gallium atoms, on the other hand, contract. Since the gallium atoms only contract by a small amount, this leads to a positive thermal expansion coefficient in one direction. However, the material can be prepared and processed so that there is an almost equal and opposite contraction in the other two directions. This results in a negligible overall volume change in the unit cell.

“We hope that these results will allow us to look for zero-expansion materials among semiconductors and intermetallic compounds, which had not been thought of before now,” Kapetanidis said.

Physics Web

Extracting electricity from water

Engineers in Canada have discovered a new way to generate electricity. Larry Kostiuk and colleagues at the University of Alberta pumped water through tiny microchannels in a glass disk to directly generate an electrical current (J Yang et al. 2003 J. Microchem. Microeng. 13 963). “This is the first new way to produce sustainable electricity in 160 years,” says Kostiuk. “It allows for the direct conversion of energy of moving liquid to electricity with no moving parts and no pollution.”

When a liquid, like water, comes into contact with a non-conducting solid, the solid surface becomes charged with a thin layer. The dimensions of the microchannels used in the Canadian experiments were comparable with the thickness of this charged layer. This means that if water is then forced through the channel, ions with an opposite charge to the surface preferentially pass through it, and ions with a like charge stay behind. This results in the channel becoming positive at one end and negative at the other - like a battery.

If the channel ends are connected together by a wire, current flows. Although the current through an individual channel is very small - about a nanopamp - it can be increased by forcing the water through a large number of parallel channels.

Kostiuk and co-workers used a glass disk 2 centimetres in diameter that contained 450 000 circular microchannels, each between 10 and 16 microns across. They held a reservoir of water 30 centimetres above the array and allowed it to flow through the disc under hydrostatic pressure, generating a current of 1500 nannamps in the process. The power output could be improved by increasing the pressure drop, adjusting the size of the microchannels, decreasing the thickness of the glass disk or using a liquid with a higher salt concentration.

Physics Web/New Scientist

Gold plating on the cheap

Researchers in the UK and Sweden have created a new material that could cut costs in the electronics industry. Lidijsa Siller at the University of Newcastle and colleagues in Durham and Göteborg have developed a simple method to mass-produce thin films of gold nitride. In addition to being cheaper than the gold-plating methods that are currently used to make electronic components, gold nitride also offers improved performance (S Krishnamurry et al. 2003 Phys. Rev. B to be published).

Nitrides are typically more durable than their parent metal so researchers have long believed that gold nitride could be used as an alternative to gold itself. However, gold nitride has proved difficult to synthesise - despite twenty years of effort.

Siller and co-workers have now used a technique known as ion implantation to make gold nitride. They confirmed the presence of the nitride with photoemission spectroscopy and found that it had a novel triclinic structure. This structure is predicted to be metallic and should therefore be suitable for applications.

“Our method produces harder, conductive gold coatings - which do not require the addition of environmentally damaging trace elements - by a relatively ‘clean’ and inexpensive process,” says Siller. Moreover, gold nitride is more hard-wearing than the materials currently used, which means that manufacturing costs can be reduced by using thinner plating layers.

Physics Web
AUSTRALIAN GOVERNMENT SPACE FORUM
14 November, 2003
Australian Government Minister for Science, Peter McGauran MP and Industry Parliamentary Secretary, Warren Entsch announced the establishment of the Australian Government Space Forum to be chaired by the Department of Industry, Tourism and Resources. It will bring together senior representatives from 20 Government agencies with space related interests and meet every six months to facilitate the exchange of space-related information and to better improve cooperation on whole-of-government space issues.

The Australian Government Space Forum and the Internet space portal will:
- improve the information flow between Australian Government agencies and space stakeholder groups; and
- provide a focal point for national and international inquiries on Australian Government space activities.


$1.2 MILLION GOLDEN HANDCUFFS FOR OUR BEST SCIENTISTS — Applications open for prestigious Federation Fellowships
18 November, 2003
Dr Brendan Nelson announced the opening of the application round for the Howard Government's prestigious Federation Fellowships for scientific research.

A Federation Fellow receives an annual salary of more than $230,000 — with an equal amount contributed to their work by their host institution. This makes them the most valuable publicly funded research positions in Australia.

This is the third year of the Fellowships. So far 48 world class researchers have won the Fellowships including:
- seven researchers from the UK, four from the US, three from Germany, one from Sweden, one from Hong Kong, and one from the Netherlands;
- five researchers, who have returned to Australia from Cambridge in the UK; and
- two researchers, who have returned to Australia from the prestigious Max Planck Institutes in Germany.

Federation Fellows are now leading the world in research on robotics, photovoltaic solar power, optical fibre technology, the history and philosophy of science, drug design, and genetics. Up to 25 of the Fellowships offered under the Australian Research Council's (ARC) National Competitive Grants Program are awarded each year of the five-year scheme.

Open to applications from outstanding international researchers, the Federation Fellowships program particularly encourages applications from Australian and non-Australian researchers currently working overseas. A preference will be given to early- to mid-career researchers who will play a leadership role in building Australia's internationally competitive research capacity.

Applications for the 2004 Federation Fellowships will close on 6 February 2004. Information and application details for the 2004 Federation Fellowships are available through the ARC's website at www.arc.gov.au

REFORM TO ARC GRANT ASSESSMENT PROCESS
21 November 2003
The Australian Research Council (ARC) has advised Dr Nelson of its intention to improve its grant peer review process.

The ARC had been asked to take a careful look at its model for managing the grant assessment process — particularly how grant assessors prioritise grants across different disciplines and socio-economic objectives.

They came back with a proposal to break down the existing Expert Advisory Committees that assess grants and replace them with a remodelled “college of experts” that will prioritise funding decisions across the widest spectrum of disciplines, providing consistency with the government's National Research Priorities, and enhancing taxpayer accountability.

All applications to the ARC are currently subject to rigorous peer assessment. The proposed changes will improve the consideration of multidisciplinary grants, and will ensure the best possible decision-making about grants targeted at different social, economic, and cultural objectives.

Dr Nelson also wrote to Tim Besley AC, Chair of the Australian Research Council, requesting that consideration be given to including broad community representation on the new body that will be assessing future grants proposals.

CRCS IN THE SPOTLIGHT
24 November 2003
From transforming the sugar industry to tackling polluted waterways, the CRC program has had a very successful year and the many achievements of the CRC program have been highlighted in a book launched by Australian Government Science Minister Peter McGauran.

"CRCs = Connecting Communities is a snapshot of the ongoing benefits to Australia in manufacturing, information and communications, mining and energy, medicine, agriculture and the environment from the many and varied CRCs in the program," Mr McGauran said. "CRCs bring together universities, research organisations, government and industry to cover these six important sectors for Australia's health, environmental and economic prosperity."

"This year there will be a record 71 CRCs, sharing $200 million of Government funding," he added.

Further information on the CRC program can be found at http://www.crc.gov.au/

$28 MILLION ANSTO UPGRADE
27 November 2003
The Australian Nuclear Science and Technology Organisation (ANSTO) will increase radiopharmaceutical production and improve its main entrance following parliamentary approval of two public works projects.

The $17.9 million building works include an extension to the north and east of the existing radiopharmaceutical production building. They will comprise modern chemistry laboratories, production clean room facilities, packaging and dispatch facilities, and wash bays. The new $10.3 million main entrance at ANSTO is funded by the Australian Government and arose from a reassessment of security and traffic issues.

REWARDING AUSTRALIA'S BEST UNIVERSITY TEACHERS
2 December 2003
Eight Australian academics and five universities were recognised for dedication, professionalism and enthusiasm which sets them apart. They are winners of the 2003 Australian Awards for University Teaching (AAUT).

Professor Ian Cameron from the University of Queensland has been awarded the top honour — the Prime Minister's Award for University Teacher of the Year. Professor Cameron also won a Teaching Award in the category of Physical Sciences and Related Studies and so received total grants of $75,000 to continue valued work in his field.

Winners in the Teaching Award categories receive a grant of $40,000 each. Institutional Award winners receive $50,000 each, from a total grant pool of $605,000.

The Australian Awards for University Teaching were established in 1997 to celebrate and raise the status of Australian university teaching. The Minister congratulated all those academics and institutions recognised by the awards.

Other finalists in the Physical Sciences and Related Studies category were: Dr Peter Petocz, University of Technology, Sydney and Associate Professor Helen MacGillivray, Queensland University of Technology.
conveys potential changes to the cell body where potentials above a threshold trigger impulsive potential changes that propagate down the axons to the axonal tree, where they reach synapses with other neurons. We retain separate populations of excitatory and inhibitory neurons, named for their effects on the firing rates of other neurons on which their axons impinge.

The neural response to the cell-body potential is incorporated by noting that a single neuron's firing rate is zero below threshold and rises very steeply to a maximal rate above it. In a population with a variety of thresholds, this step-like response is smeared out into a sigmoidal curve, approximated by

$$Q_s(V_a(r,t)) = \frac{Q_{\text{max}}}{1 + \exp\left[-[V_a(r,t) - \theta]/\sigma\right]}$$

(1)

where $Q_{\text{max}}$ is the average maximum firing rate, $\theta$ is the mean firing threshold, $\sigma$ is its standard deviation, and $e$ denotes a particular population of neurons (e.g. e = excitatory or i = inhibitory).

Fig. 2. Schematic of a typical neuron. Input synapses are located on the dendrites, while output synapses are on the axonal tree.

If the response of synapses and dendrites to incoming signals were instantaneous, the cell-body potential would simply be the sum of the incoming mean firing rates, weighted by the mean numbers and strengths of synapses. In reality, synaptic inputs are summed after being filtered and smeared out in time as a result of synaptic dynamics and passage through the dendritic tree, the resulting cell-body potential approximately obeys an equation of the form

$$\frac{1}{\alpha^2} \frac{d^2}{dt^2} \left[\frac{1}{\alpha} \frac{d}{dt} \right] V_a(r,t) = \sum V_{sb} \phi_b(r,t - \tau_{sb})$$

(2)

where $\beta$ and $\alpha$ are the rise and decay rates of the cell-body potential produced by an impulse at a dendritic synapse. Equation (2) is written for a neuron in the cerebral cortex; the sum over neural types $b$ on its right comprises mean incoming pulse rates $\phi_b$ and $\phi_i$ from excitatory and inhibitory cortical neurons, and inputs $\phi_b$ from the thalamus delayed by a time $\tau_{sb} = \tau/2$ due to anatomical separations between cortex and thalamus, where $\tau_b$ is the time to traverse the loop from cortex to thalamus and back ($\tau_{sb} = 0$ for intrathalamic and intracortical connections). The quantity $V_{sb}$ is the mean product of the strength and number of synapses from neurons of type $b$ to type $a$.

Each part of the corticothalamic system produces a field $\phi_b$ of pulses, introduced above, that travels along axons at a velocity $v_e$. When viewed on the large scale, perturbations to mean values appear to propagate as damped waves. This prompts us to model the propagation via a damped wave equation

$$\left(\frac{1}{\gamma_a^2} \frac{\partial^2}{\partial t^2} + \frac{2}{\gamma_a} \frac{\partial}{\partial t} + 1 - r_a \nabla^2 \right) \phi_a(r,t) = S[V_a(r,t)]$$

(3)

where $\gamma_a = \gamma_b/r_a$, is the damping rate and $r_a$ is the mean range of axons $a$. The spatial Green function corresponding to this equation is found to closely approximate the observed range distribution of cortical axons.

Including only the connections shown in Fig.1 and making some further physiologically-based approximations, we find that our model has 16 parameters: $Q_{\text{max}}$, $\theta$, $\alpha$, $\beta$, $\gamma_e$, $r_a$, $t_0$, $v_e$, $v_i$, $v_{ee}$, $v_{ei}$, $v_{es}$, $v_{se}$, $v_{es}$, $v_{se}$, $v_{ee}$, $v_{ei}$, $v_{es}$, $v_{se}$. These are sufficient in number to allow adequate representation of the most important anatomy and physiology, but few enough to yield useful interpretations and enable parameter estimation by fitting predictions to data.

They are also approximately known from experiment, leading to the indicative values in Table 1.

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<th>Quantity</th>
<th>Nominal</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{\text{max}}$</td>
<td>340</td>
<td>s$^{-1}$</td>
</tr>
<tr>
<td>$v_e$</td>
<td>10</td>
<td>m s$^{-1}$</td>
</tr>
<tr>
<td>$r_a$</td>
<td>86</td>
<td>mm</td>
</tr>
<tr>
<td>$\theta$</td>
<td>13</td>
<td>mV</td>
</tr>
<tr>
<td>$\sigma'$</td>
<td>3.8</td>
<td>mV</td>
</tr>
<tr>
<td>$\gamma_e$</td>
<td>116</td>
<td>s$^{-1}$</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>80</td>
<td>s$^{-1}$</td>
</tr>
<tr>
<td>$\beta$</td>
<td>500</td>
<td>s$^{-1}$</td>
</tr>
<tr>
<td>$t_0$</td>
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<td>ms</td>
</tr>
<tr>
<td>$v_{ee}$</td>
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<td>mV s</td>
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<tr>
<td>$-v_{ei}$</td>
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<td>mV s</td>
</tr>
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<td>$v_{es}$</td>
<td>0.4</td>
<td>mV s</td>
</tr>
<tr>
<td>$-v_{se}$</td>
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<td>$v_{en}$</td>
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<td>mV s</td>
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<td>$v_{re}$</td>
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<td>mV s</td>
</tr>
<tr>
<td>$v_{rs}$</td>
<td>0.03</td>
<td>mV s</td>
</tr>
<tr>
<td>$\phi_{n}^{(0)}$</td>
<td>16</td>
<td>s$^{-1}$</td>
</tr>
</tbody>
</table>

Table 1: Nominal parameters from Ref. 12 for the alert, eyes-open state in normal adults. Parameters used in works from which some of the figures were obtained were similar, but not identical, in general.
Waves obey a dispersion relation, which determines the linear instability boundaries of the system. In most circumstances, spatially uniform disturbances are the most unstable, and it is found that only the lowest frequency spectral resonances can become unstable. Analysis for realistic parameter ranges finds just four global instabilities, which are named for historical reasons and lead to global nonlinear dynamics. These are:

(a) A so-called slow-wave instability \( f=0 \) that leads to a low frequency spike-wave limit cycle.

(b) A \( \theta \) instability, which saturates in a nonlinear limit cycle near 3 Hz, with a spike-wave form.

(c) A spindle instability at \( \omega = (\alpha \beta)^{1/4} \), leading to a limit cycle at 10 - 15 Hz.

(d) An \( \alpha \) instability, giving a limit cycle near 10 Hz.

The boundaries defined by these four instabilities are interpreted as corresponding to onsets of generalized seizures.

The occurrence of only a few instabilities, at low frequencies, enables the state and physical stability of the brain to be represented in a 3D space with \( x, y, \) and \( z \) axes that parameterise cortical, corticthalamic, and thalamic feedback strengths, respectively. In terms of these quantities, the brain occupies a stability zone illustrated in Fig.6.

Non-seizure states lie within the stability zone in Fig.6. Detailed arguments regarding the arousal sequence, from alert eyes-open (EO) to deep sleep, including relaxed eyes-closed (EC) and various sleep stages, constrain the relevant regions of parameter space and place this sequence as shown in Fig.6. In future, it is expected that known differences between EEG spectra for subjects with differing disorders will also enable classification of these conditions into different parts of the stability zone.

One common generalized epilepsy is petit mal or absence epilepsy, in which seizures last 5 - 20 s, cause loss of consciousness, but not convulsions, and show a so-called spike-and-wave cycle which starts and stops abruptly across the whole scalp. Figure 7 shows results from our model under conditions for a \( \theta \) instability. An approximately 3 Hz spike-and-wave cycle is seen, which closely resembles observed petit mal time series.

**Inversion and Parameter Determination**

To test our model and estimate some of its parameters, we fitted the parameters of its linear spectrum to 101 normal adults' eyes-closed (EC) and eyes-open (EO) spectra collected in previous studies. This yielded mean parameters consistent with those in Table 1.

The parameter values obtained using spectral fits and other model-based constraints prove to be both consistent with independent measures, and complementary to them, often yielding improved constraints on the parameters involved. This is illustrated in Fig.8, where we show constraints on the corticocortical axonal range \( r_a \) and signal velocity \( v_s \).
The European Society for Photobiology (ESP) recently held its 10th Congress in Vienna, Austria, from the 6-11 September, 2003. As with previous meetings, the programme of the 10th Congress covered all major fields of photobiology. There was a mixture of photobiology update special lectures, 37 different symposia, workshops and 2 poster sessions. Over 250 oral presentations and 180 posters were presented during the weeklong congress. The congress addressed a wide range of topics, from DNA damage and repair to the protective ability of different shade structures, which indicates the very diverse research that is being carried out all over the world. Unlike previous congresses, this year’s programme included for the first time a joint symposium co-organised by the European Photochemistry Association (EPA) and the ESP. This reflected the close association between the research being conducted by the members of both societies. Attendees of the conference came from all over the world to listen and to discuss the diverse area that photobiology entails.

The Queensland branch of the AIP recently awarded me a $500 grant to attend the congress, where I was able to present my research entitled “UV Protection and Shade Structures”. Part of a research focus in the Centre for Astronomy, Solar Radiation and Climate at the University of Southern Queensland, Toowoomba, is to provide quantitative data on the solar UV environment and UV exposures to humans. The results presented at the conference show that as the solar zenith angle (SZA) of the sun increases so does the relative proportion of scattered UV beneath shade structures which in turn decreases the shade structures ultraviolet protection factor (UPF). The public shade structures used in my research are built to be effective in the middle of the day in summer when the sun is at its highest point. In an Australian winter, the erythemal UV in full sun can reach levels of approximately 2.5 MED/h (where a MED is defined as the minimum erythemal dose) or more in the middle of the day. Therefore, it is necessary for people that live in similar latitudes to minimise UV exposure in all climatic conditions throughout the year. Based on my research, a standard for reporting the UV protection provided by shade structures is essential for the public to make an informed decision on the efficacy of particular structures in reducing personal UV exposure.

David Turnbull
Centre for Astronomy, Solar Radiation and Climate,
University of Southern Queensland, Toowoomba, 4350, Australia.
CONFERENCES & MEETINGS

2004

February 3-6 28th Annual Condensed Matter and Materials Meeting
Convention Centre Charles Sturt University, Wagga Wagga, NSW
Contact: Khuen Wong, CSIRO Telecommunications and Industrial Physics
PO Box 218, Lindfield, NSW 2070 Australia
Tel: +61 2 9413 7620 Fax: +61 2 9413 7200
Email: Khuen.Wong@CSIRO.AU
www.tif.csiro.au/wagga/

April 19-21 1st Pacific International Conference on Application of Laser and Optics (PICALO)
Melbourne, Australia
Contact: A/Prof M. Brandt mbrandt@swin.edu.au
Tel: 03 9214 5691
www.laserinstitute.org/conferences

August 23-27 5th International Conference in Biological Sciences (ICBP2004)
Chalmers University of Technology & Gothenburg University,
Gothenburg, Sweden
Email: info@inspireevent.se
Website: http://fy.chalmers,se/icbp2004

October 24-27 29th Australasian Radiation Protection Society Conference 2004
Novotel Hotel, Adelaide, Australia
Contact: Sapro Conference Management
PO Box 187 Torrensville, SA 5031
Tel: (08) 8352 7099 Fax: (08) 8352 7088
Email: sapro@ozemail.com.au

October 25-30 The 9th Asia Pacific Physics Conference (9th APPC)
Ho Chi Minh Museum, Hanoi, Vietnam
Contact: 9th APPC Secretariat,
Institute of Materials Science
18 Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam
Tel: +84 4 7564129 Fax: +84 4 8360705 Email: appc03@ims.ncst.ac.vn
Website: www.ims.ac.vn/appc03
cle with his handbacked support of science output in government labs. Means well but is narrow minded in his belief and understanding of 'good science'."

Also depressing, and somewhat surprising to me (though I'm now told that Physics Heads of department meetings have provided this impression for some years) has been the response from those identifying themselves as University Professors and/or heads of department. I had suspected my own university workplace was somewhat of an oasis, however I perhaps hadn't appreciated just how lucky I was. I would have thought that at the professorial/head of department level the perspective would have been overwhelmingly optimistic. Not so. To date there have been 17 such responses, of which exactly half paint a grim picture indeed of physics in the Universities. I spent a bit of time trying to see how I would quantify grim. Here are some grim responses;

Science culture
- "Done on a shoestring in most cases. Funds are strategically directed into a few favoured areas. Most teaching development is inadequately funded."
- "Far too much administration by people who do not have a clue what research is."
- "Too many non-local and non-scientist people in charge."
- "The general public don't have much time for science or care for it."

Work environment
- "Too much paperwork, insufficient trust. Too many changes, too often."
- "Ordering and purchasing even basic bits of equipment is always delayed (and often cancelled) because of ridiculous administrative policies."
- "Management does not listen."
- "Rapidity and frequency of change to Faculty/Divisional Structures and courses must be reduced. Teaching load is extremely high putting great pressure on teaching quality, and for those undertaking research, a great deal of stress on academic and family relationships."

Work output
- "Too much Government and University red tape."

There were more but these capture the essence.

I sorted the responses into three groups: grim, optimistic and in-between, and then searched for associations. It turns out that in this 17 response professorial/head of department set there was a 100% correlation between those responses that appeared to be grim (in my own view of course) and those which had answered negatively to my poorly worded morale question. Those that I took to be optimistic answered positively and the one response that I thought was in-between actually left the question unanswered. So, using the morale question as a means of quantification, I can say that for the 17 responses of this set (which is a pretty large set of data for this particular group of people) I can characterise 50% of them as grim.

Extending this methodology to the non-professorial/non-head of department university replies (including students and staff), in this set there were 19 (35%) optimistic replies and 35 (65%) grim replies. This is as would be expected from the results of the professorial set, since at higher levels people are more likely to have a happier perspective, being at the head of their discipline with generally permanent positions, higher levels of research funding and higher rates of pay. In government labs the grim proportion is 55% though I note there was a stronger suggestion of extreme grimness from many of the grim responses there. Among school teachers it was 54% grim. And for those who believe that the results might be tainted because of a stronger response from grim people - well fair comment - but the hole in that argument, and one of the very positive things I can point to so far from this questionnaire, is that the physicists doing 'other' work are a relatively happy group with only 20% of the responses being grim. Well done guys, it was good to have your response and to see where physicists are in the greater community.

Many of course would know from experience that Physicists are a hard working lot. Soon the survey will provide the statistics to back that up. The overwhelming majority of respondents are working more than a 40-hour week. There are some part time people, and my hat's off to those retirees who still have enough love of physics to come in each week and enjoy their time teaching or in the lab. But to those who want it there will be ammunition to level at any politician who dares to suggest that a stereotype of lazy academics applies to the Physics discipline! We are indeed a dedicated lot, from teachers to academics to researchers and others. Based on what I've received to date, if nothing else comes from the physics culture survey, this will certainly be there, and that is enough to cheer my day. It will however take longer to determine whether we actually love our work or not and whether we're encouraged to carry it out.

Of some concern to me have been the responses to question 15 of the questionnaire "Reports provided to upper management levels at my work place?" Though the majority who have responded assert that they provide unbiased reporting to upper management, there are many who assert that they provide positively biased reports. Having been schooled in a train of thought where it was believed that a scientist should have an "objective" neutral perspective (though perhaps I have only succeeded in this myself to lesser and greater degrees), I was somewhat shocked to see the strength of the positive bias response: 37% of government lab responses, 36% of non-professorial/non-head of department university responses, 66% of professorial/head of department responses, 35% of school teacher responses, but only 17% of responses from physicists in the 'other' employment set. I think we have to ask why aren’t we providing unbiased reports? What? What do the responses say? All the written responses to this question are provided below.

From the Professorial/Head of department set:
"The school naturally tries to put a good spin on things to maintain its funding base."
"If I write a report of course I will make it positively biased."
"We have a largely optimistic and positive outlook."
"Science meets Parliament" is a remarkable event, which brings scientists and Parliamentarians together for intensive discussions on the national investment in science and research. Professor Chris Fell, President of FASTS, said that only five out of 226 federal Parliamentarians had a background in science. "We need to build better links between science and Parliamentarians," he said. "We have found that MPs are really interested in talking science. They want to know what science and technology can deliver, and more about the possibilities for new industries and solutions for environmental problems."

From a full list of 17 topics nominated in the national research priorities, the MPs selected the following three issues as of the greatest significance to them:

- Water - a critical resource
- Overcoming soil loss, acidity and salinity
- Frontier technologies - new industries of the future

SmP 2003 is the fifth annual SmP meeting, and the biggest yet. Registration numbers were noticeably higher than last year, with 25 more Parliamentarians and 40 more scientists participating than in 2002. 152 Parliamentarians accepted an invitation to talk about science.

SmP 2003 commenced at 10 am on Monday October 13, when Science Minister Peter McGauran launched the Science meets Parliament flag on the front steps of Questacon. During the week, 80 flagpoles in Kings Avenue and Commonwealth Avenue carried the brightly coloured flags, providing a conspicuous reminder of the SmP 2003 activities to Canberra residents and parliamentary staff.

Scientists spent one day at the National Press Club to prepare for the meetings with parliamentarians. FASTS Executive Director Toss Gascoigne explained "Why we are here and what's going to happen." Kieran McLeonard of ABC Radio then chaired a discussion by a panel of scientists on their experiences in meeting Parliamentarians. Andrew Nette, NTEU commented on making the most out of meetings with MPs. Dr Thomas Barlow, adviser to Dr Brendan Nelson, and Bradley Smith, former Democrat staffer, advised the scientists on communicating effectively with MPs.

As well as meetings with individual parliamentarians, there was also a feisty debate between Science Minister Peter McGauran and shadow spokesperson Senator Kim Carr, a discussion led by Dr Ken Baldwin, Chair FASTS' Policy Committee, and Dr David Denham, Vice-president FASTS on "The issues of the Day" and meetings between young scientists and young Parliamentarians.

A dinner at Old Parliament House provided a further opportunity for scientists and parliamentarians to mingle and exchange views. The dinner was addressed by John Wolpert, team leader of "the IBM Extreme Blue Innovation Lab" in Austin, and by Dr Graham McDonald from pharmaceutical company Merck, Sharp and Dohme, the U.K., subsidiary of Merck and Co. Inc.

More detail about SmP 2003, including transcripts of many of the talks, can be found on the FASTS website www.fasts.org

New President of FASTS

Following the Annual General Meeting of FASTS, held on Thursday 16 October, Professor Snow Barlow began a two-year term as President of FASTS, succeeding Professor Chris Fell.

Professor Barlow is a plant scientist at the University of Melbourne, where he heads the School of Agriculture and Food Systems. He says Australia has been able to maintain an enviable growth rate in recent years, largely because of micro-economic reforms carried out by successive governments over the last 15 years.

"But there is no such thing as growth. It takes more to keep a country going. It has to work hard, but on the right things. It means fostering innovation through increasing the national investment in science and research, and making more intelligent use of our capital and labour force."

He said that one of his priorities, as President of FASTS, will be to change a cultural attitude to science and technology, so that budget allocations in this area are recognised as investment rather than expenditure.

Professor Barlow paid tribute to the work of his predecessor, stating "Chris Fell has made a huge contribution to public life in Australia. He played an energetic role on the Prime Minister's Science Council, and on innumerable committees and reviews across Australia. Our scientists are deeply grateful for his efforts." Professor Barlow said the work of successive Presidents of FASTS had built a vibrant and energetic organization of 60,000 scientists and technologists.

Professor Barlow's own work is in one of the hot areas of science. He investigates the potential impacts of climate change on agricultural crops, particularly in Australia's important viticulture sector. He spent his early years on the Darling River, and graduated from the University of New England with honours in Rural Science, and degrees in cricket and rugby.

FASTS Elections, Annual General Meeting, 16 October 2003

Professor Rob Norris, Dean of Science at Monash University and Associate Professor Judy Mousley of the Faculty of Education at Deakin University were elected Vice-Presidents of FASTS. Associate Professor John O'Connor of the University of Newcastle was re-elected to the position of Secretary, and Associate Professor John Rice of Flinders University was re-elected as Treasurer.

Dr David Denham steps down after four years as Vice-President of FASTS, but remains on the Policy Committee. Chris Fell paid tribute to David's very substantial service to FASTS, noting that as a resident of Canberra, David was very frequently called upon to speak to the media on behalf of Australian scientists, which he did extremely effectively.
Product News

Ytterbium tungstate laser reaches 14 W

Engineers at Spectra-Physics have achieved record output powers from a con tinuous-wave laser that is based on a ytterbium tungstate (Yb:KGW) laser rod. The device, which has thermoelectric (TE) cooling of the laser rod, emits a stable 14 W at 1040 nm. In its latest test, the rod was end-pumped with 60-W fibre-coupled output of two diode bars. The gain medium delivers a broad bandwidth similar to materials like Ti:sapphire and alexandrite; unlike the latter two, it is not distance-dependent. Yb:KGW can be directly pumped with laser diodes operating at 940 or 980 nm. The simplest configuration for a diode-pumped Yb:KGW laser is to pump with the fibre-coupled output from one or more diode bars; the thermal management problems that are minimised through TE cooling had previously led to cracking and fractures in laser rods. The broad bandwidth of Yb:KGW offers potential for modelocked lasers and high-power amplifiers with femtosecond output.

For further information please contact:
Lasek Pty Ltd, 10 Reid St, Thebarton SA 5031
Tel: (08) 8443 8068, Fax: (08) 8443 8427
Toll Free: 1800 88 2215
sales@lasek.com.au www.lasek.com.au

New Raman PL/CL Accessory for SEM’s

Renishaw of the UK has introduced a novel structural and chemical analyser for SEM (scanning electron microscopy). It exploits the benefits of two well-established techniques – scanning electron microscopy, and Raman spectrometry – to identify and characterise the chemistry and structure of materials in a non-contacting, non-destructive manner.

The Raman effect occurs when laser light is shone on a material; light is scattered, a tiny fraction of which is shifted in frequency as atoms in the material vibrate. Analysis of the frequency shifts (spectrum) of the light reveals the characteristic vibration frequencies of the atoms and hence the chemical composition and structure of the material.

Fully retractable optics are inserted between the SEM’s objective lens and the sample, positioning an analysis spot with sub-nanometre precision and reproducibility, while retaining the capability of viewing the sample using secondary electron imaging, and analysing it using energy dispersive X-ray spectrometry.

A further benefit of this solution is that the collection optics are suitable for cathodoluminescence and photosoluminescence studies, so the electrical and physical properties of samples can also be probed at the sub-micrometre or micrometre-scale.

The analyser can be fitted to most SEM models and models. Further information on these and other specialist scientific systems is available from:
WARSASH Scientific Pty Ltd at (02) 9319 0122 or sales@warsash.com.au

40 W Fibre Array Packaged (FAP) Diode Laser Bars for Pumping Applications

By expanding the fibre array packaged bar (FAPTM) product line, Coherent now offers even higher brightness versions of the FAP. These new high power 40 W FAP products are ideal as efficient pump sources for neodymium-doped solid state lasers as well as direct diode thermal applications in medical and materials processing industries.

The 40 W bar has 19 separate emitters, each fibre-coupled to provide >2 W of optical output per fibre. These fibres are then bundled together and efficiently coupled into an 800 um multimode fibre that is terminated with an SMA905 connector for applications requiring homogenous beam delivery. Alternatively, a long fibre bundle configuration allows for delivery of laser light to more than one location for added flexibility. Typical drive current for the 40 W FAP is < 55 Amps. The new FAPs operate at wavelengths from 905 to 915 nm. Spectral width is typically <4 nm FWHM, and the numerical aperture is <0.14 NA, encompassing 90% of the energy.

The increased brightness from the 40 W FAP allows the user to take their system performance to the next level by providing higher power density to the work surface and improved design efficiencies in commercial pumping and laser systems. Described for use in integrated applications, this high power FAP is 70 x 31.8 x 25.8 mm, the same size as Coherent’s 30 W FAP products. The 40 W FAP can also be used in all of Coherent’s full-feature, microprocessor controlled FAP systems.

Please contact Bill Persentski (Bill.Persentski@coherent.com) for further information.
Coherent Scientific Pty Ltd
116 Sir Donald Bradman Drive, Hilton SA 5033
Phone: +61 8 8150 5200 or Fax: +61 8 8352 2020
Email: sales@coherent.com.au
URL: http://www.coherent.com.au

New Standard IR Uniform Source

LabSphere have released a tunable, off-the-shelf IR uniform source system for the calibration of imaging systems and electronic cameras in the VIS / NIR – MIR range. The LabSphere U.S.S-400-IG IR uniform source system, with an Infragold diffuse reflectance coated integrating sphere optimised for the longer wavelengths, is ideal for calibrating and testing IR imaging sensors, IR based camera systems and IR targeting systems, thermal imagers, photometers & radiometers.

The uniform source integrating sphere collects the radiation from the source and uniformly integrates that radiation to create a uniform field of light within the sphere. Integrating spheres offer researchers a wider wavelength range of radiation, and a constant colour temperature range at every level of luminance. The exit port aperture of the sphere provides nearly perfect Lambertian radiation that is diffusionally emitted from the exit port plane and serves as a virtual surface of uniform luminance or radiance when viewed through an optical system. The plane of the exit port exhibits uniform illuminance or irradiance for objects or devices placed against the port and serves as the calibration source aperture.

With the USS-400-IG, technicians can accurately and easily calibrate sensors and imaging systems with a variable output source providing uniform irradiance in the 660nm to 5mm range. The spectral content can be modified without the breakdown and realignment of traditional optical benches.

Please contact Warranoh Scientific at (02) 9319 0122 or sales@warranoh.com.au for further information on the LabSphere USS-400-IG and other uniform source and calibration systems for remote sensing/electronic imaging systems.

Spectra-Physics Introduces Thin-Disk Laser for Industrial Marking Applications

Spectra-Physics has introduced the DiQ-Mark, a Q-switched, thin-disk laser that delivers a combination of cost and performance benefits for marking and precision machining applications. The DiQ-Mark is a highly reliable, diode-pumped Nd:YAG laser that generates up to 8 watts of near infrared output with good beam quality (M2=4), and pulse repetition rates up to 50 kHz.

The Q-switched, near infrared output enables this laser to create surface marks on many organic materials, including most plastics, as well as on a wide variety of metals, such as aluminum and anodized aluminum. It also delivers higher intensity, resulting in deeper or faster marking as compared to lamp-pumped lasers with inferior beam quality. Additionally, the DiQ-Mark laser is well suited for uninterrupted, 24 hour operation in other precision machining applications, such as engraving and scribing.

The DiQ-Mark provides all the advantages of diode-pumped construction as compared to lamp-pumped lasers. These include high reliability, good beam quality and a compact footprint. In addition, the use of thin-disk technologies in the an air-cooled architecture that is inherently simpler, easier to integrate, more power efficient, lower cost and more rugged than conventional diode-pumped lasers. The DiQ-Mark is constructed with its pump diodes in the power supply, their output is coupled into the laser hosts through optical fiber. This facilitates system maintenance and eliminates the need for optical realignment after laser power replacement. This lower cost of ownership derived from these factors makes DiQ-Mark an attractive alternative in applications still using lamp-pumped lasers.

For further information please contact:
Coherent Scientific Pty Ltd, 10 Reid St, Thebarton SA 5031
Tel: 08 8443 8668, Fax: 08 8443 8427
Toll Free: 1800 88 2215
sales@coherent.com.au www.coherent.com.au

New from Redlake! The high speed, high resolution MotionXtra HG-100K digital imaging camera

The MotionXtra HG-100K high-speed, high-resolution digital imaging system features an exclusive 1.7 megapixel CMOS sensor offering a true replacement for high-speed film cameras. Capable of recording from rates of 1 frames per second (fps) to an incredible 100,000 fps, the camera includes a fast 5ms global electronic shutter to eliminate motion blur and deliver razor sharp images during the recording of extremely high-speed events.

The HG-100K is designed to operate in the most challenging and rugged environments and delivers high-quality images through a combination of exceptional light sensitivity, high resolution and increased speed not found in any other CMOS based camera.

Features of the MotionXtra HG-100K imaging camera include:
- High-resolution 1504 x 1128 pixel CMOS sensor (exclusive to Redlake)
- 1,000 fps recording rate (at full resolution) and up to 100,000fps (partial resolution)
- Very short 5ms electronic shutter to eliminate motion blur
- Rugged design to withstand up to 100 G in any axis
- 1000Base-T Ethernet interface for networking and fast data transfer
- MotionCentral Windows-based application software
- Supports various file types including Type-2 Bayer, JPEG, TIFF and 24-bit colour data
- 2 Gbyte on-board memory (expandable to 4 Gbyte)
- The superior resolution and speed of the HG-100K system along with the flexibility necessary to meet the requirements for integration into data acquisition, analysis and testing systems makes it ideal for many high-speed imaging applications. Typically, these include:
  - Time-resolved particle image velocimetry; Range, Aerospace and Ballistics - weapons impact testing and space vehicle launch; Automotive - vehicle impact testing and airbag development; Design and testing applications - function and performance testing of high-speed components

For more information please contact Dhar Garcez (Dhar.Garcez@coherent.com.au),
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Phone: 1800 8150 5200 or Fax: +61 8 8352 2020
Email: sales@coherent.com.au
URL: http://www.coherent.com.au
now to the extent that it was with us, he regarded laboratory work as being absolutely central to the understanding of physics. So every week in the last two years of school we'd spend a morning doing physics experiments. Just as importantly we were required to write comprehensive reports".

It was this grounding in experimental physics that made Stacey such a good experimenter and innovator in later years.

**Undergraduate and postdoctoral years**

He did well in his last year at school and won a scholarship to university. Again it was his grandfather who encouraged him to further his education. He went to Queen Mary College at London University and was straight away enrolled in the Honours physics course. He found studying at London University a very challenging experience. "There was much more competition and it was a challenge. It was a welcome challenge in a way because discussions in the refectory with other students were often as informative as the lectures themselves". At the University he was to come under the influence of G. O. Jones whose research interests were in low temperature physics. He had selected Stacey from among the other students as a student who would go far. Jones, according to Stacey, was "a mover and shaker in the department". Being a younger man than the Head of the Department who was close to retiring, Jones had surrounded himself with over ten PhD students, Stacey being one of them. His project was on the effects of very high pressure on ferromagnetism. While Jones, as a supervisor, was "helpful in the sense of encouraging", he was, however, "not helpful in terms of having detailed knowledge of what I was doing", Stacey said. In fact, he left Stacey very much to himself.

After obtaining his PhD, Stacey went as a Research Fellow to the University of British Columbia in Canada. There he worked on projects in low temperature physics that were initiated by the Canadian Defence Research Board. In particular, they wanted a solution to the trouble they were having with their Geiger counters in the Arctic but by the time he got there the parameters of the project had changed. "So it became the study of the properties of liquid argon and helium under bombardment by alpha and beta particles". This was an important period of his life. "I regarded the period that I spent at the University of British Columbia, about two and a half years, as an opportunity to drop my PhD blinkers and grow up". It was while he was doing his post-doctoral fellowship there that he had the leisure of browsing through the journals and looking at interesting topics. It was on one of these scans through the scientific literature that he came across an article by Louis Neel on the theory of rock magnetism. "Neel clearly understood magnetism extremely well, but not only that, explained it extremely well. Rock magnetism looked like a fascinating subject. I said, ah ha, I think that is the way I want to go".

Now fate conspired to bring Stacey to Australia. It was the fifties and the Australian National University had just been established with much fanfare in Canberra. John Jaeger had been appointed Head of the Department of Geophysics in the in the Research School of Physical Sciences. Jaeger had been the head of the Mathematics Department at the University of Tasmania and was an expert on heat conduction in solids. He had done his postgraduate studies at the University of Cambridge but, on failing to obtain a research fellowship at Trinity College (the fellowship was awarded to Subramanyan Chandrasekhar, an astrophysicist who was to win a Nobel prize in 1983 for studying physical processes of importance to stellar structure and evolution, including the prediction of white dwarf stars), had taken up an appointment at the University of Tasmania. Jaeger began building his department and had collected a number of young, enthusiastic researchers, including Edward (Ted) Irving who had begun work on palaeomagnetism to answer the question of the drifting of continents which was a contentious issue in scientific circles at that time. Irving was of the opinion that palaeomagnetic measurements in Australia "ought to provide a critical test for the hypothesis of continental drift".

The idea of continental drift was proposed by Alfred Wegener in 1912. It initially arose from the observation of the apparent fit of the bulge of eastern South America into the bight of Africa. From this observation it was proposed that the lands bordering the Atlantic Ocean had once been joined. In support of his hypothesis Wegener plotted the distribution of orogenic belts, geologic contacts, paleoclimatic zones and living and fossil plants and animals. According to Wegener all the landmasses had been joined in one large protocontinent, he termed Pangaea. The land mass began to breakup in the Jurassic about 190 million years ago to give us the location of the present day continents. The westward drift of the Americas opened the Atlantic Ocean and the Indian block drifted across the equator to merge with Asia. In the 1930s, Wegener's hypothesis was modified by the suggestion that there were two primordial continents, viz: Laurasia in the north and Gondwanaland in the south.

Wegener's hypothesis not only sparked worldwide interest but also much violent opposition to the idea. The strongest opposition came in the 1920s from Harold Jeffreys, an influential English geophysicist and Plumian Professor of Astronomy at Cambridge University. His main objection rested on his argument that the force of gravity is stronger than any known tangential force acting upon the Earth's crust to move the landmasses. His arguments found expression in six editions of his book *The Earth*. However, by the 1960s, when the physicists came into the picture, they began to change the intellectual mood in favour of Wegener. The change came about from the magnetic studies conducted by P. M. S. Blackett at London University and S. K. Runcorn at Cambridge University and later at the University of Newcastle-on-Tyne. Blackett - who had won the Nobel Prize in 1948 for studying nuclear physics with cloud-chamber photographs of cosmic-ray interactions - began a series of experiments in rock magnetism. At about the same time Bullard's predrift reconstruction of the continents bordering the Atlantic by a computer program to find the best fit of the Atlantic margins helped to dispose of some of the earlier arguments that the fit is very poor or nonexistent.
Stacey's group worked in a number of areas in geophysics, including thermoremanence in rock magnetism, earthquake prediction and the thermodynamics of the Earth. While still at the Australian National University, Stacey had realised that the property of thermoremanence was central to an understanding of rock magnetism. This was the remanence that is acquired by igneous rocks as they cool. Neel had developed a theory of thermoremanence in single domains. However, according to Stacey, "it didn't really appear to be completely relevant because most of the grains in rocks are not single domains but multidomains". So he developed a theory for multidomains. However, it subsequently became evident that there was an intermediate size range, which is called pseudo-single domains.

According to Stacey, "one of the questions which I was asking when I was in Queensland was - what is really the domain structure within the grains? That's something we need to understand and indeed, your own PhDs was directed very much at that question. The theory of thermoremanence fitted observations really well for grains larger than about twenty microns, but in the meantime, I had some misgivings about the theory. In particular, if the domains were really randomly oriented, then there ought to be a mean squared direction cosine of their orientation entering the theory and this would introduce a factor one third, which didn't seem to be there and I wanted to know why. So that was the point of my career when you came into it, and answering that question was really the point of your experiment, which was to induce an anisotropy in a rock by applying a strong field to it and then watching that anisotropy relax as you heated it. Did the relaxation have the same thermal spectrum as thermoremanence or did it disappear much more easily. And, of course, what you found is that it disappeared much more easily. Which said that that factor of one third is not relevant to thermoremanence because the grains are behaving as though they're intrinsically isotropic. There is no random direction; the individual grains have all directions of domains effectively within them. Now that was, I think, in terms of understanding the properties of large grains, quite an important step. But it also became apparent that we were seeing much stronger thermoremanence in small grains, even those that were too big to be single domains. That was the beginning of the pseudo-single domain theory which is now, perhaps almost the central subject of rock magnetism, because pseudo-single domains have the most stable remanence and so they're of the greatest interest in paleomagnetism".

"Pseudo-single domains" was an expression coined in Stacey's early papers and "It has stuck" in the scientific literature according to him. In 1986 an AGU (American Geophysical Union) meeting had two special sessions on pseudo-single domains and Stacey gave the opening invited talk. Pseudo-single domains represent one of Stacey's scientific successes.

The magnetostrictrion question that was mentioned earlier became the starting point for Stacey's foray into studies concerning the advance warning of volcanic eruptions and earthquake prediction. His studies had led him to a realisation that there was a possible magnetic effect associated with earthquakes. Working on this hunch he had sent Malcolm Johnston, then a graduate student, equipped with a differential proton magnetometer to New Zealand. Johnston set up the equipment on the volcanoes Ruapehu and Ngauruhoe with the collaboration of the DSIR. Eruptions of both Ruapehu and Ngauruhoe in 1968 yielded remarkable magnetic signatures. In both cases, the magnetic changes preceded eruptions by periods of several hours to several days.

Although the initial experiments were successful and led to great optimism regarding the possibility of predicting earthquakes, this optimism has not been sustained. According to Stacey, "Now that was, I suppose you should say, the most successful of the experiments, although it has not ever succeeded in predicting earthquakes. They are more complicated. The stress in the ground doesn't follow the precursory patterns we were looking for and earthquakes are still not, certainly not reliably, predictable". However, tectonomagnetism, as it became known, that is the magnetic effects of ground stress became the subject of study in several countries, especially Russia, United States and in a big way in China and Japan. According to Stacey, "It had a history before me of course, but I think it became properly quantitative as a result of our work".

Continuing his research into earthquake prediction techniques, Stacey began to look at other methods. According to him, "if we were going to be able to predict earthquakes, one technique was unlikely to do it alone and I wanted to look for some others". One of these techniques was to observe the tilt of the ground. There had been reports from Japan regarding the tilting of the ground preceding an earthquake, but the instruments used, according to Stacey, were rather crude. So he went about developing a tilt meter that would be extremely sensitive to changes in the tilting of the ground. According to him, "Now I discovered by going to the CSIRO that they'd been working on a technique of capacitance micrometry. This had been well developed at the CSIRO. It lent itself perfectly to a tilt meter because you could measure the changes in mercury levels in two connected pools as seen by electrodes in a beam mounted above them. And so as the relative capacitance is changed you're recording tilt and this became an extremely sensitive as well as a beautifully calibrated instrument". Stacey got a patent out of this. The instrument was patented through the University and it made some money for a while. However, Auckland Nuclear Accessory Company, which was manufacturing it, closed down a few years later and the instrument is no longer manufactured although the capacitance method is still proving useful in other geophysical observations.
Ongoing Support for Space Research

1 December 2003

The record-breaking Australian satellite FedSat will continue to operate until December 2005 as a result of an additional $2.75 million from the Australian Government.

"FedSat has now traveled over 200 million kilometers since it was launched from Japan on December 14, 2002," said Australian Government Science Minister Peter McGauran in announcing the extra funding. "It is the longest lasting satellite built in Australia and the first to illustrate 'self-healing' computers that repair themselves after being damaged by radiation."

The added funding will see the satellite expand its space research into space weather, navigation, communication methods, and space computing and satellite technology.

Mr McGauran said FedSat was built by the Cooperative Research Centre (CRC) for Satellite Systems, which last month received a National Engineering Excellence Award for the project.

The judging criteria included the contribution of the work to Australia's economy; its impact on quality of life; significance as a benchmark of Australian engineering and the extent to which the work represents best practice.

Boosting the French Connection

12 November 2003

A new agreement will strengthen science and innovation collaboration between Australia and France.

Australian Government Science Minister Peter McGauran and French Ambassador, His Excellency Patrick Renauld, co-signed the French-Australian Science and Technology Programme, which will fund joint French and Australian research initiatives.

"This new programme will create stronger science and innovation links between our two nations by building partnerships between Australian and French researchers, bringing benefits to both countries," Mr McGauran said.

Mr Moullet's drive has been crucial in improving the science and innovation relationship between our countries and his work in establishing key networks, has been of considerable benefit to the French and Australian research communities," concluded Mr McGauran.
Quantum Entanglement Retangled

There is a crying need for a book setting out what is known about the strange quantum phenomenon of entanglement, even if it cannot be explained. "Entanglement - the Greatest Mystery in Physics", by Amir Aczel, was to this reader a disappointment. It started well with an explanation of entanglement that a physics student could follow, but beyond a lay reader. Then went downhill by referring to the father of nuclear physics as Lord James Rutherford. The remainder of the book was in my view just as patchy. Explanations of crucial experimental tests, real and gedanken (such as the famous Einstein, Podolsky and Rosen paper), were incomplete. And some of the diagrams were either mislabeled or misleading, or both. I thought I knew something about beam-splitters through various lab experiments, but the switching of beam-splitter positions in the triple entanglement experiment has me foxed. I'll just have to go to Greenberger, Horne and Zeilinger's original paper to sort it out. I shouldn't have to do that.

This book could have been a winner. Careful rewriting could still redeem it. Having re-read it several times without greatly expanding my knowledge, I feel frustrated. Mind you, the book does contain some interesting historical angles, but I want to improve my knowledge of quantum entanglement resulting from the superposition principle inherent in the Schrödinger equation, not the sex-life entanglements of Schrödinger himself, interesting though they may be.

So I acknowledge my own shortcomings in this bizarre aspect of physics, and am admitting defeat by passing the book on to a more experienced reader, whose review follows.

Colin Keay
Reviews Editor

Reviews

Entanglement - The Greatest Mystery in Physics
Amir D Aczel
John Wiley & Sons, Chichester, 2003
xviii + 284 pp., AS44.95 (hardcover)
ISBN 0-470-85046-9

Aczel's book tells the bare story of the discovery, progressive analysis and experimental testing of quantum 'entanglement' (superposed correlated n-particle states, n > 1) against non-quantum ('hidden variable') alternatives, lightly coloured with some biographical details (and omitting a few key entries, such as the 1935 papers by Furry on EPR). Quantum mechanics wins.

It is always a plain, sometimes a pedestrian, accounting: one unhappily too elementary for physics students while too cryptic and too blimshod for lay readers. Too cryptic because key expressions like 'phase' are constantly left unexplained, as are the main points of many discussions, e.g. why spin has no classical analogue. The blimshes are exemplified by these (late-on) remarks on uncertainty: "Properties of momentum and position, for example, cannot be known to any given precision. Once measured ... a quantum object is no longer in that fuzzy state in which quantum systems are..." (p. 243) Competent readers will be able to clean up the several ineluctities in this passage so that the falsehoods that otherwise threaten are excluded. The novice will flounder. The flat, sometimes hesitant, recounting is unrelated by any fire of the adventure of the big ideas involved: no discussion of ideas of physical intelligibility and physical realism since Newton, the geometrisation programme and topological dynamics, etc. There is the occasional error, such as contradictory claims on pp. 222 and 224 about the p. 224 figure and the b, b' reversal on the p. 215 diagram, in a typo-free text.

C. A. Hooker
Philosophy Discipline, School of Liberal Arts
University of Newcastle

Giant Magnetoresistance Devices
E Hirota, H Sakakima and K Inomata
Springer-Verlag, Berlin 2002
ix + 177 pp., EUR 64.95 (hardcover)
ISBN 3-540-41819-9

This is a very informative monograph in an area in which the research literature is well spread and comprehensive reviews relatively sparse. The three authors have each contributed two chapters with a seventh chapter being shared. This has allowed each to concentrate on their expertise, although occasionally resulting in topics being introduced or explained more than once. The English is very good throughout, with only the occasional piece of slightly clumsy expression reminding us that they are writing in their second language.

The book aims at providing an overview of the present and future electronics applications of GMR and its relatives. The authors are all solid state physicists and the explanations are all couched in these terms. Starting with the physics of GMR and Tunnel junction Magnetoresistance (TMR), the book works through the operation of spin-valve devices and their use as read heads, projected TMR read heads, the current state of magnetic RAM (MRAM) and finally the bipolar spin transistor, spin FET and related devices.

One excellent feature is the large number of diagrams throughout the entire book. These add enormously to the understanding of the material, whether it is through schematic diagrams to illustrate the physics or depictions of experimental results. I can strongly recommend the book for a coherent and understandable description of a very topical area.

John Cashion
Physics Department
Monash University

The Dating Game
Cherry Lewis
Cambridge University Press, 2002
ix + 258 pp., AS32.95 (paperback)
ISBN 0-521-89312-7

This book describes the development of isotope geochemistry and its application to dating rocks and measuring the age of the Earth. It is hard to believe that less than a hundred years ago people had no clear idea of the Earth's antiquity. Lewis shows the development of ideas on the Earth's age through a biography of scientist Arthur Holmes. Holmes' research career spanned the discovery of radioactive decay and Rutherford's prediction that it could be applied to date rocks, through a revolution in thinking about the age of the Earth. Holmes was one of the first people who could be described as a geochronologist.

A brilliant student at the Royal College of Science, Holmes first learned about radioactivity from Professor Robert Strutt who had worked at the Cavendish Laboratory in Cambridge. In 1910 Holmes was the first person to develop a method of dating rocks by measuring lead rather than helium as the daughter product of uranium. The U-Pb dating method has since become one of the most widely used and successful dating methods of our time. In 1913 Holmes wrote a landmark paper on the age of the Earth based on his measurements of uranium and lead where he
crystalline anisotropy in transition metals and of spin-orbit coupling in non-collinear magnetic structures. Other highlights include application of local density approximation to complex magnetic structures, and the discussion of double exchange interactions in perovskite manganites. The discussions of magnetism in (III,Mn)N V semiconductors and in 4d transition metal oxides were not useful to me. It may be that these topics are not mature enough for such a treatise.

In summary, I was challenged by the detailed theoretical developments and impressed by the success of density functional theory to explain the behaviour of a number of archetypal magnetic systems. However, I was distracted by poor definition of terms (particularly acronyms) which often appeared without explanation, and numerous other minor editorial flaws.

I have gained a greater appreciation of interplay between electronic and local forces in determination of magnetic order and I would recommend this book to researchers with strong interest in this area.

SS J Kennedy
The Bragg Institute
ANSTO

Dynamics of Dissipation
X + 512 pp., EUR 89.95 (hardcover)
ISBN 3-540-44111-5
It has become increasingly common to find the proceedings of a meeting, or a collection of papers by the invited speakers published as a single issue in some of the best journals. A typical shortcoming of this is that each paper has a single specific focus but the complete set of contributions lacks a central theme. It was therefore a pleasure to find an exception here. This volume contains the invited lectures from the 38th Karpacz Winter School of Theoretical Physics, "Dynamical Semigroups: Dissipation, Chaos, Quanta" held from 6 to 15 February 2002. The editors have gone to great lengths to develop a theme while bringing together two otherwise separate groups of researchers.
Non-equilibrium statistical mechanics of classical and quantum systems are traditionally separate fields but here there has been a serious attempt to bring together these two endeavours. The essential ingredient is that each contribution has been expanded to a full review chapter.
I would recommend this book, based simply on my reading of the first beautifully written chapter by Eddie Cohen (but that betrays my own research bias). He begins with the SRB measure and the fluctuation theorem, then considers statistics and entropy, finally looking at the separate attempts by Tsallis and Beck to provide a quantitative analysis of the statistics of two real experiments. There are other very good contributions by Gaspard, Dorfman, Rondoni and D Cohen. However, the value of this volume is that it helps give students and other researchers a view of "the big picture" in nonequilibrium statistical mechanics.

Gary Morrisey
School of Physics
University of New South Wales

Morphology of Condensed Matter
xviii+439pp., EUR 89.95 (hardcover)
ISBN 3-540-44203-0
The book under review is the Proceedings of the Second International Wuppertal Workshop on Statistical Physics and Spatial Statistics, held during 5-9 March 2001. Condensed matter physics embraces solid and liquid states of matter in which the constituent atoms/molecules are sufficiently close. Since a liquid does not have its own geometrical form, the title of the book appears misleading. However, the papers contributed by a number of well-known authors belong to the area of soft matter science. Because of the diverse range of topics I shall not attempt to review individual papers for space logistics. The editors have done a commendable job by providing an elaborate preface where the individual papers are amply commented.
Without following a strict distinction the editors present the articles in two parts: (i) complex structured condensed matter and (ii) spatial statistics and morphology. Part (i) deals with materials, such as porous media, foams, microemulsions, liquid crystals and complex biological systems. In view of recent experimental progress, spatial statisticians and applied mathematicians are increasingly interested in these systems. In this part of the book, shape and connectivity of spatial domains is the main focus. In part (ii) three-dimensional imaging technology is presented showing complex topologies and geometries in terms of spatial arrangements. Statistical quantities like correlation functions and distance distributions are used for this study.

In short, this book presents a state of art description of a rapidly growing area of research. Undoubtedly it will be a good reference for the specialists working in soft condensed matter science.

Mukunda Das
R S Phys S E
Australian National University

Quantum Field Theory in a Nutshell
A. Zee
xvi + 518 pp., US$49.50 (hardcover)
ISBN 0-691-01019-6
This is a book you can judge by its cover. The dust jacket features an 1800s painting of a reaper in a wheat field stretching off to the horizon. Zee takes us on an idyllic journey to some horizons of quantum field theory. The emphasis is on relativistic field theory, although condensed matter applications are not ignored. Conceptual overviews are favored over technical details.
You can probably guess if the book's conversational style is for you by considering some of the section headings. "Staring into the fire" introduces the Dirac equation and refers to the legend that Dirac was staring into a fire when he realised that he needed an equation linear in the derivatives. "Parametrization of ignorance" introduces the concept of quantum field theories as effective theories valid up to some energy scale. However there are an equal number of more conventional titles such as "Grassman path integral", "Superconductivity", and "Homotopy groups".
I recommend this book to physicists with a basic knowledge of quantum field theory who would like to catch up with some of the modern directions without getting bogged down in technicalities. There are exercises and solutions, and a good index. It should be of use to students who wish to get a contemporary overview of the subject, and hence should be in any university library. However, if you want to know how to calculate you will probably need to study Weinberg's "The Quantum Theory of Fields".

Craig Savage
Department of Physics
Australian National University
Retired Prof. John Prescott was presented with an AIP 'Outstanding Service to Physics Award' at the 13th AINSE Nuclear Techniques of Analysis Conference held in Sydney during 26-28 November 2003.

In addition to his impressive teaching and research career, John has served the Physics community in Australia by producing his invaluable annual report on Physics employment statistics and job advertisements. This data has provided important insight into Physics careers in Australia and has helped the AIP understand the needs of its constituency, as well as providing an indicator for the state of Physics as a discipline. He has provided this service, with regular reports published in the Physicist, for over 25 years, despite retiring from the University of Adelaide in 1989.

John's thermoluminescence laboratory at the University of Adelaide has made a major contribution to our understanding of the geology, climate and human colonisation of the Australian continent, including a recently published paper in Nature that provides a definitive date for the Lake Mungo burials. This date (40 kyr) is consistent with the Out-of-Africa model for human colonisation of the Australian continent and is an important contribution to this controversial debate.

John was presented with the Outstanding Service to Physics Award in acknowledgement of his outstanding contributions to the Australian Physics community. (Despite his apparent youth, John turns 80 y.o. in May 2004.)
"Laser ... inter eximia naturae dona numeratum plurimis compositionibus inseritur"

Pliny, Natural History, XXII, 49

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COVER: Front cover images courtesy of Dr. Trevor Smith, Photophysics & Photochemistry Group, University of Melbourne, VIC. For details see Page 156.

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Retrospective
At this time of year, the relentless sound of Christmas carols in all the stores serves as a reminder that the year is drawing to a close. As well as a time for overspending and overindulging, it is also a time for reflection — when you have time to pause to catch your breath between the preparations. So, reflecting over this year as editor, I find that I have a mixture of emotions, as you would expect. I have really enjoyed getting back in contact with Physics again — even if not in a direct way. I have enjoyed interacting with the people involved. Of course, I have felt some frustration too — Especially when I either have to find one extra page or delete three.

However, the main disappointment for me is that illness prevented me producing the full six issues this year. Unlike holidays, illness doesn't give us the opportunity to organise in advance. On the positive side, I did get to see an impressive array of medical technology.

Prospective
After the hustle and stress of the festive season, there is a short period of calm as the New Year stretches before us. This brief respite allows us to look ahead, rather than behind; to plan for the coming year. Well, we haven't quite reached the period of clam yet, but I have done some planning towards a bumper issue for January/February.

In this issue: The human brain is always an interesting subject and this issue has an article on brain waves by the 2002 Boas Medal Winner, Professor Peter Robinson. The article is based on the talk he gave at the medal presentation. There is also a third biography by Rabir Bhatal: this time about geophysicist Frank Stacey and it includes a fascinating account of his role in the acceptance of the theory of Continental Drift.

Scott Butcher has written a follow-up to his article on Science Culture (The Physicist Vol 40 No 3) and it includes a preliminary assessment of some of the results from the questionnaire.

You'll also find, on the FASTS page, an account of the recent Science meets Parliament day.

Acknowledgement
In the first issue this year, there was an article called Oils ain't oils but the story had reached me without the name of the author. I can now rectify that omission as Dr Matti Keentok of the School of Aerospace, Mechanical and Mechatronic Engineering at Sydney University has contacted me to claim authorship.

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AUSTRALIAN INSTITUTE OF PHYSICS

ANNUAL GENERAL MEETING 2004

The 41st Annual General Meeting of the AIP will be held in the Conference Room, School of Physics, University of Melbourne on Thursday 12 February 2004 commencing at 6:00pm.

AGENDA:

1. Apologies, recording of proxies
2. Minutes of the 40th Annual General Meeting
3. Business arising from the minutes
4. President’s report
5. Treasurer’s report
6. Special business: Change to Constitution
   (Revised constitution posted at www.aip.org.au)
7. Any other business

COUNCIL MEETING 2004

The 2004 Council Meeting will be held in the Conference Room, School of Physics, University of Melbourne on Thursday 12 February and Friday 13 February 2004. The meeting will be chaired by the AIP President, Professor Rob Elliman.

In addition to the National Executive and Chairs of State Branches, those invited to Council include: the Convenors of AIP Topical Groups, the National Science Policy Convenor, the Editor of the Physicist, the National Education Convenor, and the Presidents of the AIP’s six Cognate Societies (Australian Optical Society, Australian Acoustical Society, Astronomical Society of Australia, Vacuum Society of Australia, Australasian College of Physical Scientists and Engineers in Medicine, and the Australian Society for General Relativity and Gravitation.)

A report on the Council will be published in the March/April issue of the Physicist.

For further details please contact the Honorary Secretary
secretary@aip.org.au
Nanotechnology research projects receive grants

Nanotechnology research projects have received four out of the 12 grants made to Flinders University in the latest round of funding announced yesterday by the Australian Research Council.

Flinders University has an international reputation for its ground-breaking research and teaching in nanotechnology, and the research projects will contribute to the advancement of microfluidic engineering, the development of silicon-based micro-sensors to detect water contamination, the creation of chemical sensors that will be used for environmental and medical diagnostics, and development of a new ophthalmic biomaterial.

Professor Chris Martin, the University’s Pro-Vice-Chancellor (Research), said the funding for the nanotechnology projects represented clear recognition of the strength and quality of research in a complex and challenging field which is characterised by interdisciplinary collaboration.

“It is pleasing that our level of investment in this area has been rewarded,” Professor Martin said.

Projects to receive funding under the Discovery program include an investigation of bonding between molecules using high-resolution electron momentum spectroscopy; a study of the effect of climate change on fauna using sleepy lizards and their parasites; and a detailed study of political preference and participation in 19th century America.

Projects to receive funding under the Linkage program, which funds collaborative research with industry partners and external bodies, include a research project to assist the introduction of new technologies in regional areas and a study of the role of the Australian Industrial Relations Commission.

Flinders University Press Release

Nature reports quantum leap by UQ scientists

Australian and U.S. scientists have made a major breakthrough towards the development of the next generation of computation, the very fast quantum computer. In a world first, they have reported successfully building and testing a C-NOT gate, an essential component to enable quantum computers to work. The gate was built using single particles of light, “photons”.

Researchers from The University of Queensland (UQ) and the University of Illinois made the breakthrough, which is published today in prestigious international journal, Nature.

Project team leader Dr Andrew White of UQ’s School of Physical Sciences said in the every day world, objects were either here or there.

Current computers were based on this premise, with bits that were either on or off. However, in quantum mechanics things were different.

“Objects can be in two places or ‘states’ at once,” he said. “This is famously illustrated by Schrödinger’s cat, which can be simultaneously alive and dead (and presumably somewhat confused by it all). Similarly, quantum bits - qubits - which carry information can simultaneously be on and off.”

Dr White said interest in quantum computers has grown since it was recognised that quantum computers could, in principle, solve certain hard problems that are effectively impossible to solve with conventional computers. Quantum computers, by exploiting properties of quantum information, make many attempts to solve hard problems at the same time, speeding up the process.

In theory, quantum computers using qubits could solve problems impossible with conventional computers, such as cracking codes or weather forecasting.

“The critical component necessary for a quantum computer to work is a Controlled-NOT (C-NOT) gate: a gate that lets one qubit control the state of another,” he said. “If one qubit is simultaneously on and off, then both bits can become entangled - that is, correlated in apparently impossible ways. It is entanglement that makes quantum computing so powerful.”

Until recently no one had fully demonstrated a C-NOT gate. However, the researchers from The University of Queensland reported successfully building and fully testing a C-NOT gate.

In a world first, the UQ team demonstrated that their gate reliably makes one qubit control another. Using an automated tomography system developed in UQ’s Quantum Technology Lab, Dr White reported that if one qubit is simultaneously on and off, the UQ gate produces highly entangled qubits.

University of Qld media release

DNA self-assembles nanotube transistor

Researchers at the Technion-Israel Institute of Technology have used the self-assembly of DNA molecules to build electronic devices from carbon nanotubes. The DNA acts as a scaffold for positioning a single-walled carbon nanotube at the heart of a field-effect transistor, as well as a template for the metallic wires connecting the device (K Keren et al. 2003 Science 302 1380).

Erez Braun and colleagues have built on their work on “sequence-specific molecular lithography” to assemble a carbon nanotube field-effect transistor. They used a three-strand homologous recombination reaction between a long double-stranded DNA molecule and a short auxiliary single-stranded DNA. These DNA molecules encode the information to guide the assembly process: the short molecule has a sequence identical to the long one at the desired location of the transistor.

Braun and colleagues made 45 devices in total. Fourteen acted as field-effect transistors with partial or full gating, and ten conducted but could not be gated - probably because they contained metallic rather than semiconducting nanotubes.

“Carbon nanotubes will be one of the major future building blocks of molecular electronics due to their small dimensions and excellent electronic properties,” said Braun.

“However, you cannot self-assemble a circuit directly with nanotubes because they lack recognition. Our research demonstrates that you can harness biology to self-assemble nanoelectronics.”

Physics Web/New Scientist

Why Don’t Alcohol and Water Mix Well?

Bartenders who make cocktails shouldn’t worry about trying to get alcohol and water to mix completely. Nature prevents even the most patient drink-makers from fully blending the two. Studying methanol, a simple non-drinkable alcohol that nonetheless can provide insights into ethanol, or drinking alcohol, a US-Swedish collaboration (Jinghua Guo, LBL, 510-495-2230) has obtained new molecular-level details of why water and alcohol don’t mix very well. Using LBL’s Advanced Light Source, the researchers performed x-ray emission (XE) and x-ray absorption (XA) spectroscopy, which allowed them to study such things as the chemical bonds that form between molecules in the liquid over timescales of picoseconds to femtoseconds.

Looking first at a liquid of pure methanol, the researchers observed the presence of rings and chains made of 6-8 methanol molecules. When they mixed methanol and water, they found that the 6-8 molecule chains connected with water molecules to form larger water/methanol clusters. These clusters are very stable, because of the (hydrogen) chemical bonds that hold them together. But the water/methanol clusters also have a high amount of order, thereby reducing the liquid’s overall disorder (entropy). Yet entropy must stay the same or increase in the liquid. So nature discourages the formation of more clusters in the liquid, and this can explain why alcohol and water don’t like to mix completely. In addition, the research sheds light on a 40-year controversy over the molecular structure of pure methanol liquid, and the structures that are formed when water and methanol combine. For example, other researchers had suggested that water surrounded methanol in a static, ice-like structure. (Guo et al., Physical Review Letters, 10 October 2003).

Physics News

Can a Single Gas Bubble Sink a Ship?

The Physicist Volume 40, Number 5, October/November/December 2003

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Gravity discovery centre opens at UWA research centre

Over the last two years, a stunning public science, art/environment museum and education centre unlike anything else in the world has been quietly taking shape adjacent to a major research facility of The University of Western Australia north of Perth near Gingin. The Premier, the Hon Dr Geoff Gallop, opened the Gravity Discovery Centre on Thursday, November 6, 2003.

Funded by donations from the corporate world, the centre aims to revitalise science education and reverse the decline in science graduates, while being an exciting tourist destination.

It is a gallery of ideas, a gallery of concepts and a gallery of questions - the big questions of the universe. A huge team of scientists and artists has collaborated to create art that has grown out of the quest to understand space, time and the universe. Some of Perth's top innovators and entrepreneurs have sponsored displays that show Western Australian innovations and the creativity of local inventor.

An enormous pendulum tower houses a set of extraordinary pendulums that mysteriously gain energy and move to hidden forces. Acoustic devices allow you to hear yourself in the past. Supermagnets exert unbelievable forces and light slows down. Lasers expose curved space and telescopes become time machines. Sound artists explore the sounds of gravity waves and a giant mural depicts the history of the universe. Waves ripple across the floor and a giant mosaic depicts the largest single structure in the universe.

The pristine environment is all around and an aboriginal heritage shield tree provides a focal point and a link to the traditional custodians of the land.

The centre includes the biggest public astronomy centre in the Southern Hemisphere and the largest telescope in Western Australia. Daytime viewing of stars is possible, as well as a 1km scale model of the solar system. A bunkhouse allows overnight stays for astronomy, while Stargazers Café even serves fresh barramundi.

The centre is the public arm of the Australian International Gravitational Observatory and it will be opened by the Premier of Western Australia, along with Australia's pre-eminent Cosmologist and science communicator Professor Paul Davies (winner of the Faraday Medal and the Templeton Prize) at 10.30am on Thursday 6 November.

Einstein's theory of the universe is portrayed in giant graffiti artwork on the west wall of the building.

Newcastle University excels with Engineering Challenge

The University of Newcastle excelled at the Engineers Australia National Excellence Awards in Canberra.

The University's Science and Engineering Challenge, a program devised by the Faculty of Engineering and Built Environment and the Faculty of Science and Information Technology, won the top award of the night, the Sir William Hudson Award for most outstanding engineering project.

Challenge administrator Bob Nelson says he is thrilled with the outstanding result. "We are running a program which the judges have said has had a greater impact on engineering in Australia in 2003, than any other engineering project," said Bob.

"It's been an outstanding year for the challenge which expanded outside of New South Wales for the first time. Over 4000 students from 128 schools competed in science and engineering challenges."

"Since the challenge has been running it appears that there has already been a dramatic turn around in the participation in the enabling sciences in secondary schools that have competed in the Challenge program. This is a direct result of the Challenge which combines fun and interesting tasks such as cracking codes, solving a virtual maze, predicting the path of a bouncing ball and making a chair that will hold a certain weight."

AIBN for UQ

Work will begin next year on the $60 million Australian Institute of Bioengineering and Nanotechnology (AIBN) complex at the University of Queensland.

UQ Vice-Chancellor Professor John Hay announced the AIBN complex on November 26 when Queensland's Innovation and Information Technology Minister Paul Lucas presented a cheque for $5 million for the project.

The State Government will contribute $17.5 million to the AIBN through the $100 million Smart State Research Facilities Fund. Other funding for the complex, scheduled to begin in July 2004 and open in late 2005, has been sourced from a private benefactor - The Atlantic Philanthropies ($17.5 million) and the University ($15 million).

Professor Peter Gray has been appointed inaugural Director, joining UQ from the University of New South Wales (UNSW).

A number of University researchers, and the Australian Research Council (ARC) Centre for Functional Nanomaterials, will be housed in the new AIBN complex.

The ARC Centre, headed by Federation Fellow Professor Max Lu, is developing nanomaterials for health, clean energy and environmental technologies.

The complex will also house the UQ Centre for Nanotechnology and Biomaterials, headed by Professor Matt Trau, which is designing artificial human organs and tissues less likely to be rejected by the body.

Happy Birthday to Questacon

On 27th November, Australia's world-renowned National Science and Technology Centre, Questacon, celebrated 15 years of bringing science to life.

Australian Government Science Minister Peter McGauran congratulated Questacon, saying that over the years they had played a vital role in raising community awareness about the important role science plays in our daily lives.

Questacon was originally set up in the old Ainslie Infant School in Canberra, before moving in 1988 into its current premises on the shores of Lake Burley Griffin. "With the help of a small government grant, Dr Mike Gore started Questacon and now, each year, they reach over a million people from Australia and overseas," Mr McGauran said.

Questacon's major outreach programme is the Shell Questacon Science Circus. This unique programme gives university students the chance to learn to communicate science to non-scientists. At the same time it takes practical and fun demonstrations into schools around Australia.

NOBLE PRIZES

The 2003 Physics Nobel Prize

The 2003 Physics Nobel Prize goes to Alexei A. Abrikosov (Institute for Physical Problems in Moscow and now at Argonne National Laboratory near Chicago), Vitaly L. Ginzburg (Lebedev Physical Institute, Moscow) and Anthony J. Leggett (University of Illinois, Urbana).

The award goes for work done on systems that operate under two regimes very far from human experience: the quantum realm and the low-temperature realm. In superconductivity, a current of electrons flowing through a material undergoes a change in behavior: normally reluctant to associate with each other, the electrons at low temperature can form pairs. These pairs act like particles and are so gregarious that they can enter into a single unified quantum state.

The 2003 Nobel Prize in Physiology/Medicine

The 2003 Nobel Prize in Physiology/Medicine goes to Paul C. Lauterbur of the University of Illinois at Urbana-Champaign and Peter Mansfield of the University of Nottingham for their work in developing magnetic resonance imaging, or MRI.
BRAIN WAVES

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Introduction

Electroencephalograms (EEGs) result from cortical electrical activity aggregated over scales much larger than individual brain cells, or neurons. They probe timescales down to ms, but are restricted to spatial scales above roughly 2 cm, owing to the presence of skull and scalp tissue, which limit the proximity of electrodes to sources, and thus out localized potentials because of their appreciable conductivity. EEG measurements are thus complementary to slower (many seconds), but finescale, methods like magnetic resonance imaging (MRI).

EEGs have a wide variety of forms, illustrated in later sections, that are known to be correlated with different states of arousal (e.g., wake vs. sleep), pathologies (e.g., schizophrenia, Parkinson's disease, epileptic seizures), and cognitive tasks (e.g., mental arithmetic, stimulus discrimination). Despite this, and despite brain electrical activity having been observed since 1875, the reasons for most of these connections have remained shrouded in obscurity, leaving to most information contained in EEGs being discarded.

Work on quantitative analysis of EEGs at the University of Sydney started in 1996 when Chris Rennie, a Senior Medical Physicist in the Brain Dynamics Centre and Department of Medical Physics at Sydney's Westmead Hospital, started a PhD on this topic. After establishing its essential feasibility, we aimed to (i) develop a theory with no free parameters, unlike prior attempts, and (ii) be able to determine underlying brain parameters by fitting predictions to data.

Continuum Theory

Since EEG signals are only observed on scales of cm or more in practise (mm or more in the related electrocortical recordings, made with electrodes placed on the brain surface during surgery), there is no need to model every neuron separately. Hence, in continuum theories, averages are taken over microscopic neural structures to obtain continuum descriptions on scales of mm to the whole brain. Historically, these theories have incorporated various subsets of the anatomical and physiological features discussed in the next paragraphs, but those prior to our work had undetermined parameters that could be varied at will, and also neglected brain structures that have since proved to be essential for a quantitative description of the main phenomena.

In contrast, we have developed a physiologically based continuum model of brain electrical activity that reproduces and unifies many features of EEGs and related linear and nonlinear phenomena, which we discuss in later sections.

Anatomically, one key structure that must be included is the cerebral cortex, which comprises most of the volume of the human brain and lies closest to the recording electrodes. The other is the thalamus, at the centre of the head, which is the key gating station for all external stimuli, except the sense of smell, relaying them to the cortex for further processing. It also receives feedback from the cortex, leading to closed corticothalamic loops, as seen in Fig. 1, which also separately shows the key reticular thalamic nucleus which acts to inhibit other thalamic functions when it is stimulated by them or the cortex: it is a critical control structure, that enables sleep and appears to be involved in controlling attention.

![Fig. 1. Schematic of corticothalamic interactions, showing the cortex and the relay and reticular thalamic nuclei, along with the pulse rate fields $\phi_i$ that project between them. Locations ab are also shown, with which the synaptic weights $w_{ab}$ are associated. (a,b = e,i,r,s).](image-url)

Among the physiological features to be incorporated is the dynamics of individual neurons, averaged over large populations. A typical neuron is illustrated in Fig. 2, showing inputs to dendritic synapses (i.e., junctions, usually chemically mediated) with other neurons. It also shows the dendritic tree that...
\[
\frac{\phi_e(k,\omega)}{\phi_s(k,\omega)} = G(k,\omega)
\] (4)

Results

Setting all derivatives to zero in (2) and (3) yields steady states when the system is driven by a constant, uniform mean stimulus level \(\phi_0\). The equations are easily solved numerically, yielding a single stable low-\(\phi\) solution, which corresponds to a normal state. Other steady states are either unstable or have extremely high \(\phi\) and presumably correspond to seizures\(^8\), which are discussed below.

Small perturbations relative to steady states can be treated using linear analysis. A stimulus \(\phi(k,\omega)\) of angular frequency \(\omega\) and wave vector \(k\) has the transfer function which is the cortical excitatory response per unit external stimulus, and can be written explicitly in terms of the parameters in Table 1\(^9\).

The EEG frequency spectrum is obtained by squaring the modulus of \(\phi(k,\omega)\) and integrating over \(k\). Figure 3 shows excellent agreement with an observed spectrum over several decades if \(\phi_0\) is assumed to be white noise in space and time—a reasonable approximation, given the spatiotemporal complexity of the totality of incoming stimuli. The features reproduced include the alpha and beta peaks at frequencies \(f = \frac{1}{\tau_0} = 10\) Hz, 20 Hz, and the asymptotic low- and high-frequency behaviors. The low-frequency \(1/f\) behavior is a signature of marginally stable dynamics, which allow complex behavior, implying that the normal brain operates close to instability\(^8\) and probably enhances its adaptability to changing stimuli. The steepening above 15 Hz is due to lowpass filtering by dendrites and synapses.

Wave-number spectra result if one integrates \(\phi(k,\omega)^2\) over frequency. We have found good agreement between the resulting predictions and data over more than two decades in wavenumber, with spectral knees appearing at inverses of each characteristic range of an axonal population in the brain\(^10\).

The degree of coherence between signals measured at different locations on the scalp can also be computed by Fourier methods from the transfer function. Again, the results are in good agreement with observations as a function of frequency at fixed separation\(^11\). One key feature is that coherence peaks correspond to spectral peaks, reflecting the fact that weakly damped waves can reach high amplitudes (hence a spectral peak) and propagate far before dissipating (hence high coherence). This correspondence, automatic when viewed from the perspective of wave physics, was previously cryptic in the neuroscience literature.

Figure 4 shows model time series for parameters illustrating eyes-open, eyes-closed (but awake), normal sleep, and deep sleep states. The features seen strongly resemble those of the corresponding experimental data (Steriade et al. 1997, Nunez 1995, Niedermeyer and Lopes da Silva 1999).

We predict that the inverse Fourier transform of \(\phi(k,\omega)\) for an impulsive form of \(\phi_0\) should yield the so-called evoked response potential (ERP) that results from a sudden stimulus. Our work shows that the result agrees well with experiment\(^13\), as illustrated in Fig. 5. Significantly, the model parameters used are almost identical to those that reproduce the same subject's
Independent constraints obtained by standard physiological means, shown dashed, define a rectangle consistent with all such constraints. Model-based constraints, shown dotted, then severely restrict the consistent parameter combinations to a small trapezoid.

Among these constraints is one deriving from fits of $\chi^2$ to observed spectra, which yields the narrow diagonal band shown; others arise from fits to spatial spectra and coherence data. Further details of the constraints are discussed elsewhere, along with similar analyses for numerous other variables.

**Commercialisation**

The ability to measure brain parameters using our methods is already being commercialised as part of the intellectual property underpinning the $5 million float of the Brain Resource Company on the Australian Stock Exchange in 2001. This company, now valued at circa $40 million, has compiled a large database of normal brain function measures, including our physics-based ones, and a range of automated analysis tools. By obtaining good statistics on standardized data, it is possible to compare individual subjects' measures with those of normal individuals with the same age, sex, and other characteristics, and to quantify deviations from the typical profile. This enables the effects of disorders, medications, etc., to be probed and measured. This service is already being used in pilot studies by several pharmaceutical companies to quantify the effects of medications.

**Discussion**

Recent investigations of brain dynamics have resulted in a model that incorporates the main relevant features of corticothalamic physiology and anatomy using only 16 parameters, which can be independently constrained. Its predictions provide a unified quantitative description of a wide range of phenomena, giving excellent agreement with observed EEG spectra, EEG time series, evoked response potentials, coherence functions, seizure dynamics, and other phenomena. Of key importance is the $\chi^2$ parameter space in which the stability zone of the brain is easily visualized, and in which disorders, states of arousal, etc., can be classified. Zone boundaries are identified with onsets of seizures.

Fitting the model's predictions to data provides a non-invasive probe of large-scale physiology that yields parameter values consistent with, and complementary to, independent measures. This has the potential to facilitate testing of a range of hypotheses about vigilance, cognition, sensory systems, drug action, and brain function, on a range of spatial and temporal scales, particularly when coupled with the statistics of large numbers of subjects in standardized databases. We are also exploring parameter mapping and connections to functional MRI.

From a physics perspective, this work represents an extension of quantitative biological physics into a new field where quantitative methods have been lacking. A host of problems can be addressed with the tools now at hand, often with relatively little effort compared to more traditional areas of physics. What does require a real investment of effort is attaining a true interdisciplinary situation in which physicists address the questions that are actually of interest to neuroscientists, rather than just those which are the nearest to traditional physics in flavour.

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I thank P. L. Nunez for permission to reproduce the material in the right column of Fig.4.

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**References**


THE PHYSICIST'S
CROSSWORD NO. 11
by Baron Dud, CERN

Down
2. Walk endless slopes (4)
3. Serpent swallowing ravaged fowl seen in winter (9)
4. Vinegary as a cockney orthodox Jew is said to be (6)
5. Atomic rectangle we've made light (15, 4)
6. Tacit wrapping of wheel part by nun of different order (8)
7. Nearest neighbour isomer of alcohol with hydroxyl group removed (5)
8. (10)
12. Reportedly bad pay rate for journalist running down the middle (10)
15. A fourth rate way of talking when one can't get enough (9)
16. see 5 across
19. Of leg caught in the bush (6)
21. What am I if I do it carelessly? (5)
22. see 5 down

Across
1. Ionized gas: it's in the blood (6)
5. Arcane quotation popes (9) lied about existing for every action (5, 3, 8, 8)
9. see 5
10. Lesser quality time (6)
11. Florist's nice arrangement too smooth to be true (12)
13. Letter from Alvarez et al. (4)
14. Reach across and hover about a papist (8)
16. see 5
17. Messy eater etc. ... (8)
18. Force applied by the odd doyenne (4)
20. Heretic Colin corrected theory denounced by pope (12)
23. Two pieces left over from nuclear blast (6)
24. Final contact (8)
25. In France, the quiet medicinal dose of electrons and neutrinos (8)
26. Poles in sediment are ground objects (6)
Well the Physics culture questionnaire has been going for a few weeks now. In some future article I'll provide the results and a detailed evaluation. In this article however, I want to take the opportunity to give the viewpoints of some of the respondents and discuss some of the stronger impressions I have received to date, particularly regarding how we perceive the discipline. Is it an optimistic picture or a grim one? And how biased is our reporting? Given the large number of responses and the depth of people's input I hope that this will be the first of a number of articles outlining the written responses that you have provided. We'll see what I can get past the 'Physicist' editor (who has been very patient and supportive to date).

Now, as many of you would be aware from the article I wrote for the June/July 2003 edition of the Physicist, I have indeed worked in a very oppressive science environment. What I didn't say in that article is that I count myself very lucky to now be working in a very good science environment. With the 'Culture of no' article I had hoped to scare up enough responses to get a picture of what it's really like out there. There will always be good and bad places to work and, as a discipline, we should be continually acting to improve those environments that are less than they should be. But I also hoped to find out from this questionnaire whether the discipline of Physics has islands of happiness in a sea of gloom, or islands of gloom in a sea of happiness. Remembering that our perspectives are tinted by our experience, I don't necessarily think that the whole of Physics is the same. Without studies like this we can't get a complete picture of the discipline, only snapshots; and snapshots can be misleading.

In fact I would regard this as only a preliminary, somewhat amateurish, study and in fact, one replying Physics Professor gave me very low marks (sigh) on the questionnaire. Your help would be most welcome sir! In retrospect there were questions that could have been more succinct and I would like to find out more detail about some aspects of people's work environments. However, I think one of the most important things this survey will tell us is that we need to know more. We should be more active in monitoring our own discipline and we should do it regularly. Studies of this type can educate us and others, and give us ammunition to defend ourselves. Physics as a discipline has much to offer to Australia, and if that benefit is to be imparted then we need to do more than bury our heads in the sand and hope for the best. We need to do more than hope that everyone else will see the obvious logic in maintaining our discipline. If physics is to survive we need to actively defend it at every opportunity. That means at times we may have to do unpalatable things - stand up and shout out when things aren't as good as they could be. But we need the facts at hand to do this. This isn't always easy and, according to the science culture survey, something we've perhaps been actively avoiding. So now a few rough and ready impressions of my own. With 160 replies to date the response so far has been excellent, and my thanks to those who have retired (18 responses); to science teachers (13 responses); to those in industrial labs (5 responses); to those in government labs (35 responses); to those in universities (68 responses), and to those in other positions not necessarily physics related (21 responses). I was particularly heartened by the responses from this last category. My thanks also to those respondents who may not be AIP members, and to those who receive the Physicist overseas. We are interested in the whole of our discipline and your views are most welcome and useful.

The response to the "Culture of no" article has been overwhelmingly supportive. As a small sample, this reply on the back of the questionnaire envelope from a Research Scientist at a government lab:

"I read your article after filling in this form. Really great! Send it to the minister, Chief Scientist, Senator Kim Carr, CSIRO Union, Australian Scientist, Newspapers etc."

and this, by email

"I was very pleased to read your article in the Physicist this month - I think you capture the essence of our miserable existence in a government research environment."

and this

"I happened to read your article which was accidentally left on a table in the library [at work]. I am not a physicist. I am a microbiologist ... On a quick scan, I agree with what you say. ...I recognise all the characteristics you have identified ..."

There are many similar and this has, in fact, been somewhat depressing for me, since such a strong response is indicative of a lean towards the sea of gloom scenario. I was actually prepared to be hampered, not acclaimed (and would probably have been happier if I had been hampered). While we may be in bad shape, not all is doom and gloom however. There have been some extremely positive results of the survey. And ... I still have high hopes that my article may be attacked with gusto in the letter section of the Physicist. Unfortunately in the surveys there has been only one real attack, this from a 'Director of Science External Policy Programs' in a government lab who identified themself as being in non-physics employment, and who made the following comment regarding Australian science culture:

"It is complex, fragmented on the surface, but surprisingly supportive at the core. This can be seen by Scott Butcher's arti-
"Providing a negative report would jeopardise (is perceived to) promotion."

"Reports are not sought that are not good news."

From others in the University environment:

"Always necessary to put a positive spin on outcomes of management decisions."

"Only what management wants to be passed up the line."

"Reports of what has been completed are usually unbiased. Reports of what is planned are usually optimistic."

"Reports are positively biased to give the impression things are running smoothly."

"Reports are few, tend to focus on achievement but not lack of progress, not easy to ask for more resources as the most needed is people - institution goal is to do more with fewer people."

"Biased to whom. This is a poorly worded question."

"You tell them what they want to hear."

"Very few people have been so far involved in decision making."

"Always try to put the best spin on."

"Management is unfriendly towards perceived critical staff members."

"You're silly if you don't put a positive spin on things! Always negative and your opinion is disregarded as a 'whinge'."

"If you want your ideas are to be accepted they need to suit the preconceived ideas of senior management."

"Positioning for the best funding result and resource accrual."

From school teachers:

"Department material is usually full of hidden threats, this affects our management methods."

"Teachers are focused on students. Admin are focused on promotion/political matters."

"Some unrealistic viewpoints."

From Industrial labs:

"Results of decisions take a long time to appear, so you can 'get away' with over optimistic projections."

"Need to justify time/expenditure. Any negatives that are reported are generally to manage expectations about possible "stop-stoppers" Draft project briefs are positively biased in order to encourage a project to be allowed to start. Objective unbiased reporting occurs only generally at the end of a project feasibility stage when we are deciding whether to proceed to a full blown project. Once the full blown project starts then does the positive spin."

From others:

From a public servant working on policy "Top management and ministers don't want bad news. Just look at the P.M. who always pleads "no one told me.""

From an IT consultant "Limited time is available to prepare reports."

From a product development engineer "Management doesn't want negative comments."

From a TAFE teacher who has experience with negatively biased reports "TAFE is managed by career public servants."

The senior management levels are politicised to promote economic rationalist and privatisation agendas and unlimited growth of a displacing bureaucracy."

Retirees:

"My reports were unbiased."

"Excellence was based on university standards, nationally and internationally."

"These days it appears necessary to exaggerate highlights in order to get recognition. Image is all these days. In my opinion, very regrettably, that's how it is."

From government labs:

"Spin is effective in a system where short-term, time pressured, poorly defined and superficial goals have largely replaced the depth and rigor required to do genuinely world-class research."

"Verbal reports tend to be judged on the enthusiasm and marketing skills of the presenter but written reports are usually unbiased."

"Positive bias is used to executive levels so that senior managers look good at their jobs."

"That's how you retain your position and are promoted. Actual facts and performance are not very important."

"Good news generates kudos - bad news does not."

"It's all a game to make sure you look good. Words count more than substance."

"Senior management while composed largely of former researchers, no longer has any real understanding of current research. Hence a positive 'spin' on results, prospects, etc, enhances the likelihood of funding."

"It's important to report problems but many people focus on the negative because it's more interesting and compelling. I think that reports should be positively biased, provided that problems are still reported."

"Reporting face to face is more of a regal affair. More to do with politics than science. More to do with ones image and how one looks to the exec. Director."

"There is a lexicon of 'good' and 'bad' words..."

"Silly question."

But is it? Given the responses above I don't agree. There are different reasons given above for the different situations people face, but it's interesting to see how people view similar situations. I have to ask, though, what if our reports become the basis of government decision making, where is the line drawn? Are we credible as a source of information or irrelevant? Is positively biased reporting now part of our science culture? Is this the manifestation of "good news reporting" described in my "Culture of No" article? Do we go along with the flow and just give them what they want? Or can we stand back as a discipline and say hey this isn't how science should be done?

Enough. Analyze the above. Digest it. It is an indication of where we are on a number of fronts. The main question is where do we go from here?
Executive Director Retires
Mr Toss Gascoigne has announced his departure from FASTS, after more than nine years at the helm of Australia’s premier scientific body. New FASTS President, Professor Snow Barlow, has been on the Executive Committee for a high proportion of this period, including five years as Treasurer, and paid tribute to Toss Gascoigne’s work, saying that FASTS had come a long way during his time as Director.

“FASTS now has an established position as the peak council representing working scientists and technologists in Australia,” he said. “We have helped build up an important dialogue on science policy, which in the long run will have significant benefits for Australia. It is no coincidence that Backing Australia’s Ability, the largest funding package for science in Australian history, was announced in this period.”

Professor Barlow nominated a number of highlights for FASTS over the last nine years:

- The “Science meets Parliament” Day event
- FASTS’s membership of the Prime Minister’s Science Council
- Strong national representation of the views of working scientists
- The publication of a comprehensive science policy document
- A near-doubling of membership
- FASTS “occasional paper” series, highlighting areas such as the commercialisation of research
- Establishing better links with other science-based groups.

“Toss Gascoigne has played an important part in all these successes, working with the strong group of honorary members of our Board and Executive,” Professor Barlow said.

Toss Gascoigne is to take up a position as inaugural director of CHASS, the Council for the Humanities, Arts and Social Sciences. CHASS is being established to serve as a peak council representing the interests of this sector.

FASTS Policy Highlight: School Science and Mathematics Education

With the recent release of the report on science teaching and teacher education by Professor Kwong Lee Dow’s Committee (Australia’s Teachers: Australia’s Future – Advancing Innovation, Science, Technology and Mathematics, see www.dest.gov.au/schools/teaching/review/default.html) there is grave concern that the number of qualified science and mathematics teachers will reach unsustainably low levels. FASTS therefore recommends that the following policy from the Federation’s 2002 Policy Document be adopted:

“Teachers with a science degree incur a higher HECS debt and thus have a lower take home pay than their peers in other disciplines. This is a strong disincentive for prospective teachers to undertake science and mathematics degrees.

Policy 9.2 HECS liabilities for teachers should be at the lowest rate irrespective of discipline.

Strategy 9.2.1 FASTS will seek HECS equalisation to remove the higher debt burden for teachers in science and mathematics.”

Cautious response to proposed ARC changes

FASTS has responded cautiously to proposals to change the way research funding is handled in Australia.

Education Minister Brendan Nelson Minister flagged possible changes to the processes of the Australian Research Council (ARC). The proposal includes replacing the present expert advisory committees with a ‘college of experts’. The Minister has also suggested that there should be ‘broad community representation on the new body that will be assessing future grant proposals’.

Professor Snow Barlow, President of FASTS, said scientists can see advantages in using a multi-disciplinary panel to choose projects for funding. “Many advances come from multi-disciplinary approaches, and may for instance involve chemistry and biology working together to solve a problem,” he said. “But we would be concerned if people without the necessary technical knowledge were involved in a panel to choose which science projects should be funded.”

He said that Australia has a world-beating system of peer review, and underlined the importance of encouraging excellence across a broad base from mathematics to humanities.

“FASTS is warmly supportive of involving the broad community in Australia’s science programs,” he said. “The Australian public should be involved in selecting our national research priorities, and needs to be confident in the broad directions of scientific research.

“But we are puzzled about the role non-experts might play in choosing between often highly technical science proposals.”

Professor Barlow said he would be writing to the Minister to seek clarification about the suggestion.

The Mapping Taskforce and science education

The Mapping Taskforce is set to hand down its report later this week, as one of a series of government reports into science and research. But FASTS believes the Taskforce will have failed unless it addresses pervasive problems in the science education sector.

Professor Snow Barlow, President of FASTS, said the science education system had been labouring for some years. “Australia is experiencing declining enrolments in the basic sciences and an aging teaching profession,” Professor Barlow said. “The problem lies primarily in Chemistry, Physics and Mathematics.

“These are the building blocks of all science, and are fundamental to the creation of new industries and advances in health and environment.”

The Mapping Taskforce was established following the Prime Minister’s CEDA speech in November 2002. Among the issues it was directed to address were the development and retention of relevant skills for science, innovation and enterprise. The Taskforce report, along with other studies, is expected to lead to a new Innovation Statement, son of ‘Backing Australia’s Ability’.

Interacting with scientists from other disciplines is an added benefit of SmP: Dr Ken Baldwin (left), Laser Physics, Research School, ANU, chats with Prof Rob Norris (centre) - Dean of Science, Monash Uni and Assoc Prof Roger Read, UNSW.
Frank Stacey has had a distinguished career in geophysics. He is now an Emeritus Professor and maintains his professional interests as an Honorary Fellow in CSIRO Exploration and Mining. He was elected Fellow of the Australian Academy of Science in 1979, and Fellow of the American Geophysical Union in 1987. For his outstanding and original work in rock magnetism and investigating the thermal structure of the earth’s core and mantle, he was awarded the prestigious inaugural Louis Neel Medal by the European Geophysical Society in 1994. In 1960, he demonstrated that stress during cooling of igneous rock had no effect on remnant magnetism in isotropic rocks. This was basic to the development of paleomagnetism as a sound scientific discipline, as was his parallel study of magnetic anisotropies of rock. His study of the piezomagnetic effect on rocks was adopted in the 1960s and 1970s in extensive earthquake prediction programs in California and Japan. He is well known for his influential textbook on the Physics of the Earth.

I first met Stacey in the 1960s when I enrolled on a Commonwealth Scholarship for a PhD at the University of Queensland. In fact, I had come to the University to work in the area of microwave physics but was persuaded by his charm and dynamic personality to switch to geophysics. Being a young and newly appointed Reader in the Physics Department at the University of Queensland, Stacey was in the process of building a research group in geophysics. By the time I left he had several research students doing various projects in rock magnetism and geophysics. Within the first week of my arrival he had handed me his major review article, The Physical Theory of Rock Magnetism, which had appeared in Advances in Physics. It was a comprehensive discussion of an exciting new field and that swayed me to do my PhD under his supervision. Continental drift underpinned by a study of paleomagnetism, was back in circulation in scientific circles. Stacey was not only a key person in this push to investigate continental drift from a physicist’s viewpoint but also a recognised leader in rock magnetism. It was exciting to work with him as we felt that we were doing things that would have a real scientific impact. Unlike other supervisors he would join the postgraduate students at lunch in the University’s cafeteria. He built a terrific rapport within the geophysics group. One day in early 1996, Dr Gary Tuck from the Physics Department and also a former student of Stacey, rang me to say that Stacey was in hospital. So, when he got better, I took the first plane and interviewed him for the Eminent Australian Physicists Project. The interview took place in his dining room with views of lush green subtropical forest.

Early life

Stacey told me that he was a child of the depression years. Born in metropolitan Essex in England, he was the eldest of three children. He came from a middle class family “who had to work very hard”. “It was a family without any spare cash, so it was a fairly frugal existence”. His father was a production Engineer at the London Electric Wire Company while his paternal grandfather had been a headmaster. It is understandable that living in the depression years his father had placed greater emphasis on job security rather than education. “To him job security came before education and it was perhaps a little fortunate that his father, who had been a headmaster, was much more interested in education for its own sake and recognised that opportunities came from education”, Stacey said.

His grandfather took a great interest in young Stacey’s education and “it’s perhaps as much as anything, because of his interest that I got a good education”. He also ensured that young Stacey was exposed to things cultural, such as visits to museums. Stacey did well in his eleven plus examination and went to a Grammar School that catered for the more academically inclined students in England at that time. It meant that he was “in a group with the top 20 or 25% academically streamed” students. It was, according to Stacey, “fairly high pressure education. The demands were rigid. They got a class that they expected to get thorough to University admissions and not all of them did of course, but that was very much the target of the whole set up”. He had some outstanding teachers and it was this that “may have contributed substantially to my choice of physics as a discipline in the long term”, he said. “We had a physics master whose attitude to the subject just clicked exactly with me and he was clearly very influential in my life. Now one of the things which he did and which I think certainly wasn’t general then and I don’t believe it’s general
Jaeger advertised for several Research Fellows with expertise in a number of fields. “One of them was for high pressure physics and another for physics of magnetism”. As luck would have it Stacey had the appropriate expertise in both these areas. “I joined at the Australian National University and turned to rock magnetism”, he said. His arrival at the University provided a turning point in the arguments about continental drift.

“When I got there, rock magnetism and paleomagnetism were in a very interesting stage. The British groups had already concluded that paleomagnetism was indicating continental drift, but they were making measurements on rocks from North America and Europe. North America and Europe had not drifted very dramatically, so there were still plenty of members of the geological community who were not accepting continental drift. Which was interesting because originally it had been a geological idea and physicists persuaded them it was wrong. It took the physicists fifteen years to persuade them, after all, they’d been right in the first place. But that’s where I came in. One of the antagonists, as it turned out, to the idea of continental drift was John Graham at the Carnegie Institution in Washington, who had been an early prime mover in paleomagnetism, but then for political reasons at home, backed away from it. He had come to the conclusion that rocks were naturally stressed, that stress changes the magnetisation, which is the thermodynamic converse of magnetostriction and therefore, the directions of the magnetisation in rocks were all over the place and didn’t have to coincide at all with the field which induced them. That wasn’t obviously correct. However, it was a fairly forceful argument from a forceful character who already had a reputation in the subject and it needed investigating very carefully. I made that one of my principal objectives - to investigate this magnetostriction question and decide whether Graham was right or wrong”.

Graham’s objection was in the process of dealing a deathblow to the arguments for continental drift from experiments carried out on the magnetisation of rocks. Essentially his point was that this made nonsense of paleomagnetism. Stacey and Peter Stott, a graduate student working under Irving, carried out a series of crucial experiments on rocks that were magnetised under stress. They found that “if the rocks were magnetically isotropic, it didn’t matter whether they were stressed or not when they were magnetised; when the stress was released the magnetisation had the same direction as it would have had they never been stressed in the first place. So the anisotropy which was induced under stress deflected the magnetisation by just the amount which was required to cancel the effect of the deflection which was introduced by the anisotropy when the stress was released. It meant that you weren’t in trouble with paleomagnetism so long as you stuck to isotropic rocks, but of course anisotropic rocks would deflect the magnetisation anyway, even if there were no stress”. The experiments placed paleomagnetisation on a sure footing and continental drift was well on its way to being accepted in scientific circles. Wegener’s hypothesis was vindicated. According to Stacey, “paleomagnetism had very much a centre in Australia at that time. It was central to the whole subject. So it was a good place to be working from”. It was Stacey’s introduction to rock magnetism and he said, “I didn’t look back at all. That became my principle interest and I investigated a number of other problems in rock magnetism thereafter”.

About five years later, Stacey left the Australian National University to take up the position of the Royal Society Gassiot Fellow in Geomagnetism at the Meteorological Research Unit in Cambridge, England. While there he developed a proton magnetometer for use by magnetic observatories that were run by the British Meteorological Office. Although he was unable to carry out experimental work on rock magnetism he did some work on the theoretical aspects. This led to his publishing a major review article on ‘The Theory of Rock Magnetism’ and placed him along with Louis Neel and T. Nagata as one of the top experts in the world in this field. The paper had a tremendous impact on later developments in geophysics, especially in the field of rock magnetism.

Three years later Stacey and his family were back in Australia. “I suppose the decision to return to Australia was that we liked the place and this was particularly true, I think perhaps even more true, of my wife, than it was of me and her urge to come back to Australia, to some extent, was my motivation. There were positions in England. In fact, Ruimcork had offered me a position at Newcastle which I hadn’t taken”. The decision was also coloured by the fact that Stacey now had four children and he felt that the “opportunities for them would really be just a little bit better in Australia”.Jaeger also offered him a job at the Australian National University but it was to the University of Queensland that he went as a Reader in Physics.

In a sense it was a fortuitous opportunity. Hugh Webster, the Head of the department was heavily involved in University administration (one count had him on 35 committees) and the most senior staff member, Ralph Parsons, had just resigned to go to the United States. Parsons, according to Stacey was a “mover and shaker in the Department and did some of the central and important things. He ran the first year Honours class. He supervised the fourth year Honours projects, again a crucial and central activity of the Department”. Webster gave Parsons’s responsibilities to Stacey. It was a tremendous opening and Stacey grabbed it with great enthusiasm. It meant that he could start building his research team. “So I landed with these plum jobs and in particular, having responsibility for the fourth year Honours projects, gave me the fourth year class and that was the beginning of my research team”.

In previous years the number of honours students had been very small. However, the year that Stacey took over the Honours class there were twelve students. The staff had not prepared any projects for the students. Stacey took the initiative and converted his latent ideas into student projects. “That was a flying start for me and geophysics” at the University of Queensland said Stacey. “Well now, of course many of the students stayed on to do PhDs and it became evident that this was the liveliest group in the department".
The earthquake prediction research involved several experiments to detect stress in rock, in situ, by indirect methods, acoustic as well as magnetic. One of these was an investigation, by then graduate student M. T. Gladwin, of stress in the support pillars of the mine at Mt. Isa in North Queensland. According to Stacey, "This work was in progress when several theoretical physicists began to question Newton’s law of gravity by postulating the existence of a superimposed particle force of finite range". One particular theory, by Y. Fujii, proposed a repulsive force one third of the strength of normal gravity and range about 1000 m. Stacey recognised that the existence of such a force could be tested effectively by measurements in the deep ocean or deep mines and, having established a good relationship with staff of Mount Isa Mines, persuaded them to help with relevant measurements at Mount Isa, beginning in the early 1980s. The experiment immediately discounted a force of the magnitude proposed by Fujii, but a much smaller effect, of order 0.5% of normal gravity, appeared possible. This was the state of affairs in January 1986, when E. Fishbach and coworkers at Purdue University published a reanalysis of measurements in the early 1960s by R. von Eotvos, pointing to an apparent defect in the principle of equivalence of inertial and gravitational mass. They identified this with the non-Newtonian effect being sought in the Queensland mines. What had been a cautious re-examination of Newton’s law suddenly became a furious debate with at least thirty groups scrambling to find (and hurriedly publish) evidence. The confused situation in mid-late 1986 was reviewed by the Stacey group in an article that became the standard reference.

However, the intensity of international effort ensured a resolution of the question within a few years and both Newton’s law and the equivalence principle were cleared of doubt. The small effect apparent at Mt Isa was identified as an uncorrected bias in the commercial surface gravity surveys with which the mine measurements had been compared.

Apart from the theoretical studies that were directly related to the experimental program, Stacey also began working on several global scale problems, in particular the internal properties and structure of the Earth. According to Stacey, "I was aware of the arguments about what caused earthquakes and why the earth was convecting because this was an heretical idea for many years and, having a sufficient grounding in physics, I was aware that this had to be examined thermodynamically. So what I did was to set myself the task of trying to decide whether we could work out, theoretically, what was the thermodynamic efficiency of the Earth as a heat engine. It’s a convecting; there’s a lot of mechanical work required to form all these rocks; where does this mechanical work come from? Is it compatible with the heat flux? What is happening? And so the thermodynamic theory of convection, as I call it, was really a theory to work out what was the thermodynamic efficiency regarding the Earth as a heat engine". The results of his calculations showed that "thermal convection does indeed explain tectonics". He has gone on to investigate the thermodynamic properties of the deep interior.

Since retiring from the chair of Applied Physics at the University of Queensland, Stacey’s scientific work has been entirely theoretical. Extending his thermodynamic studies, he has shown that there are thermodynamic constraints on high pressure equations of state, as used to describe the deep Earth, that existing theories fail to satisfy. The implications for finite strain theory and high pressure physics generally are pointing to a new approach in which geophysics has a central role.

The above remarks are rather selective of Stacey’s wide-ranging contributions to geophysics. His textbook Physics of the Earth conveys an indication of the breadth of his coverage. Written at a graduate/advanced undergraduate level, its three editions (1969, 1977, 1992) became a standard text on fundamental geophysics for a generation of students worldwide.

Stacey has been a prolific author of research papers. His research strategy has been to get into new fields that are just opening up. He grabbed the opportunities that were offered by the new fields of scientific endeavour. This allowed him to make significant contributions and pave the way for others to follow. According to him, "I was simply being an opportunist - I saw something which could be done quickly, something which was crucial, something which was going to have a future - let’s jump in and be the first to do it and that is substantially what I did".

A highlight of his academic career was the award of the inaugural Louis Neel medal in 1994 by the European Geophysical Society. Neel was founder and director of the Centre for Nuclear Studies in Grenoble in France. He was awarded the Nobel Prize for physics in 1970 for his work and discoveries in antiferromagnetism and ferrimagnetism, which led to important applications in solid-state physics. He also made an important contribution to geophysics - the understanding of magnetic properties in rock magnetism. The terms of the medal are that it should be awarded for "outstanding achievements in the application of methods of solid state physics to geophysics". In conferring the award to Stacey the citation read that the medal was awarded to him for "outstanding achievements in the fertilization of the Earth Sciences by the transfer and application of fundamental theory of solid-state physics".

Acknowledgements

I wish to thank Professor Frank Stacey for the opportunity to interview him for the National Project on Eminent Australian Physicists, which is sponsored by the National Library of Australia as a project of national significance.

References

2. The following were members of Stacey’s geophysics group at the University of Queensland at one time or another from the 1960s to the 1990s: R. Bhathal, M. J. S. Johnston, J. M. W. Rynn, M. T. Gladwin, G. J. Tuck, S. Shamsi, S. K. Shamsi, A. S. Cheam, W-F. Leong, D. E. W. Gillingham, A.T. Linde, K.N. Wise, P. M. Davis, B. McKavanagh, R. D. Irvine, H. W. S. McQueen, A. J. Falzone,
OBITUARY
SUSZANNE THWAITES
1952–2003

Suszanne Thwaites, one of Australia’s leading acoustical scientists, died quietly and unexpectedly in her sleep in Ottawa on 7 October 2003. She was on the second day of a journey to which she had been looking forward and was, at the time, engaged in an audit of acoustical calibration facilities and procedures at the laboratories of the Canadian National Research Council. The trip would then have taken her on to visit Boeing Aircraft in the US, the Royal Aircraft Establishment at Farnborough in the UK, and relatives in the Åland Islands in Scandinavia.

Suszanne was born on 23 September 1952, and was the eldest of six children. She undertook an honours degree in physics at the University of Western Australia, followed by an MSc with a research project on the growth of hailstones in storm clouds. In 1977 she came to the University of New England in Armidale NSW to work with me on a project in musical acoustics, and this began her future career and a collaboration between the two of us that continued throughout her life.

At the conclusion of her PhD, Suszanne left Armidale and returned to Perth for a while, before taking up an appointment in 1985 as a Research Scientist in the acoustics group of what was then the Division of Applied Physics (now the Division of Telecommunications and Industrial Physics) of CSIRO in Sydney. The National Measurement Laboratory, responsible for Australia’s primary physical standards, is part of that Division, so that much of her work involved acoustical standards activities.

Over the next ten years her work began to expand and blossom, maintaining the diversity of interests that characterised her earlier activities. As well as increasing standards responsibilities, she was involved with aspects of the development of an ultrasonic gas-flow meter, with microphone design, and also with biological acoustics. Suszanne’s real opportunity came with the award to the Division of a set of research contracts by Boeing Aircraft Corporation as part of a Government requirement in relation to industrial development and aircraft purchase in Australia.

Suszanne’s project involved the development of a technique for detecting invisible impact damage in the honeycomb panels from which modern aircraft are constructed. With a small team, she developed a technique using a piezo-electric exciting probe and a similar near-by detecting probe (a “pitch-catch probe” set-up) together with sophisticated analysis software to examine wave propagation in the panel at a frequency of around 15 kHz. Over a few years the project attracted continuing interest and funding from Boeing and culminated in the development of a small but complex hand-held scanner, a little larger than a computer mouse, connected to an ordinary lap-top computer containing the software, and able to produce coloured images of any damage in the panel. The final design Suszanne named the “Bandicoot” after the cute little Australian marsupial that it resembled. It was the final stage of this project that was planned to take her, after Ottawa, to the US and the UK, where the level of interest by Boeing and the RAF in adopting the scanner for routine checks was very high, as it was also in Australia.

Suszanne’s involvement in standards-related activities was also great. Among other things, she represented CSIRO-NML on the BIPM Consultative Committee on Acoustics, Ultrasonics and Vibration, which meets in Paris to manage the distribution and harmonisation of physical standards in this area, and was also the Australian representative on the IEC working group on measurement microphones. She was also an active NATA assessor in the acoustics area.

Suszanne was promoted to Senior Principal Research Scientist in 2002, was Project Leader for Acoustics and Vibrations, Deputy General Manager for a large section of the Division, Equal-Opportunities Officer, and much more. While she was mostly quiet and even self-effacing, she was strong and outspoken on matters of principle and in the interests of those for whom she felt responsibility.

Outside CSIRO, Suszanne had strong and continuing interests in music, visual and performing arts, literature, and nature, especially birds. She was a member of the local community fire-fighting group, and active in the Australian Acoustical Society. She also assisted the Sydney Powerhouse Museum in selection matters.

Suszanne will be sadly missed for her contributions to all these areas. She was in the prime of her career and had much still to contribute. But most of all she will be missed for herself — as confidant, counsellor, mentor and friend to all those who knew her.

Neville Fletcher
predicted the base of the Cambrian period to be 500 million years old - a figure that still stands up to scrutiny today.

The Dating Game is an enjoyable read and does an excellent job of combining the history of ideas concerning the age of the Earth with a biography of one of the most important and previously under celebrated figures in the science of geochronology: Arthur Holmes.

Sue Keay
Curtin Metals CRC
University of Queensland

**Physics of Fractal Operators**

B J West, M Bologna and P Grigolini
Springer-Verlag, Berlin, 2003
Ix + 354 pages, EUR 79.95 (hardcover)

Benoit Mandelbrot's book "The Fractal Geometry of Nature" is one of the most influential books of the twentieth century. The fractals paradigm promulgated by Mandelbrot for describing complex geometries is used ubiquitously in physics with fractal scaling laws and fractal functions reported in all fields.

But Mandelbrot's work remains incomplete, at least in the physicists' sense; it does not provide a theory for the physical properties of matter, it provides purely descriptive tools. This incompleteness was promoted as an area of study by Leo Kadanoff in his stimulating 1986 Physics Today article, "Fractals. Where's the physics?"

"Physics of Fractal Operators" is a deliberate attempt to provide an answer, or at least the seeds of an answer, to Kadanoff's broad question. What are the physical laws that give rise to the dynamical emergence of fractals? For West, Bologna and Grigolini the answer comes in two parts. The first part is centred on the mathematical recognition that fractal functions are themselves not differentiable in the ordinary sense but are fractionally differentiable, and thus the evolution equations that give rise to fractals are not standard differential equations but are fractional differential equations. The authors make this point poignantly by referring to fractional derivatives and fractional integrals as fractal operators. The second part of the answer involves the construction of physically based models in terms of fractional differential equations.

This book is written in much the same tradition as Mandelbrot's "The Fractal Geometry of Nature". Like Mandelbrot's work the present book is based on a large body of mathematical work, either previously unknown or known as mathematical curiosities to the wider scientific community. Similarly, it is not a text as many of the ideas are still to be fully evolved. However the book contains sufficient mathematical and physical detail for others to learn to apply the methods for themselves.

Bruce West, like Benoit Mandelbrot, and Leo Kadanoff is one of the big thinkers of the modern scientific era and "Physics of Fractal Operators" is one of the great ideas books of our time. It may well become one of the most influential books with the paradigm of using fractional calculus to describe systems with emerging and evolving fractal complexities becoming widely used across the sciences.

This important book should be mandatory reading for all PhD students in physics, and it should be at the side of all scientists working with fractals and complexity.

B J Henry
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**Nano-electrodynamics**

H Nejo (ed.)
Springer-Verlag, Berlin, 2003
xii + 181 pp., AS175.84 (inc. GST)
(hardcover)
ISBN 3-540-42847-X

Subtitled "Electrons and electromagnetic fields in nanometer-scale structures", this book derives from a 1999 Tauloba symposium on the interaction between electrons and electromagnetic fields and is a composite of chapters written by specialist authors. It treats the interaction of electrons and electromagnetic fields at the nanometer scale where it is impossible to determine whether processes result from electromagnetic phenomenon or an excited electronic system. As such it is one of the first books dealing with this topic: i.e. the nature of the electromagnetic field at the nanometer scale.

The book contains a wealth of information for those with well-aligned interests. For example, it has a very interesting discussion of Time-Correlation Single Photon Counting (TCSPC) and a chapter entitled 'The Tunnelling Time Problem Revisited' that looks at the interesting issue of the temporal characteristics of tunnelling. However, it concentrates on scanning tunnelling microscopy and scanning tunnelling spectroscopy of single molecules with a particular emphasis on probe-induced light emission. As a consequence it provides a useful but specific perspective of nanoscale electrodynamics. The background to the book is also evident in the specialist nature of some chapters, with one chapter dedicated to scanning tunnelling spectroscopy of single fullerene molecules - clearly an area of speciality for the chapter authors.

In summary, this is a useful text for the specialist and provides interesting insight into electrodynamics at the nanoscale. However, it does not provide the breadth of material required for an introductory text book.

R G Elliott
Electronic Materials Engineering Department
Australian National University

**Electronic Structure and Magnetism of Complex Materials**

D J Singh and D A Papakonstantopolous (eds.)
Springer-Verlag, Berlin, 2003
xiv + 326 pp., EUR 79.95 (hardcover)
ISBN 3-540-43382-1

As an experimental physicist with interest in magnetic materials spanning more than two decades, I was pleased to be given an opportunity to review this book. I hoped to gain some theoretical tools that would help me to understand some of the more complex magnetic problems that confront us in the neutron scattering arena at Lucas Heights.

In general the authors of the various chapters have done well in linking density functional theory with experiment in magnetic systems, highlighting both successes and failures and providing comprehensive references in support of their discussions. This is particularly true in the discussion of low energy excitations in itinerant systems, the explanation of magnetoo
Phase Separation in Soft Matter Physics
P K Khabibullaev and A A Saidov
Springer-Verlag, Berlin 2003
ix + 180 pp., EUR 59.95 (hardcover)
ISBN 3-540-43890-4

Soft matter is the squishy part of condensed matter physics. It deals with a very broad range of materials such as polymers, gels, liquid crystals, colloids and simple liquids. It is distinguished from its larger sibling, solid-state physics, also by the fact that the problems are almost universally classical, as opposed to quantum-mechanical in nature. In the northern hemisphere it is a crucial part of any physics education.

There are few books in this area, and the best of these are indeed very good. Alas, the same cannot be said for this monograph. A book on phase separation in soft matter could readily have dealt with many of the most beautiful and fascinating examples of phase separation, such as the nematic-isotropic transition in lyotropic liquid crystals or the self-organisation of block copolymers into many fascinating microphases. Instead the authors focus on surfactant micellar solutions, microemulsions and simple liquids - subjects in themselves of much interest, but poorly treated by the authors. There are very few illustrations (except graphs), and some parts of the book, particularly the parts talking about electrons seemed to be totally irrelevant.

A quick perusal of the publication record of the authors suggests very little experience in the broad area of soft matter. The authors are from Tashkent. Perhaps this book shows the likely outcome of research that is poorly funded and carried out in isolation.

David R M Williams
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Risk-based Classification of Radioactive and Hazardous Chemical Wastes
NCRP Report No 139
National Council on Radiation Protection and Measurements, Bethesda MD 2002
xv + 433pp., US$ 55.00 (paperback)

Classification, treatment and validation of chemically hazardous and radiological wastes have traditionally been treated separately generally following separate procedures and often responsible to separate governmental authorities. This treatise brings these hitherto different approaches under a similar risk-based clarification for radioactive and hazardous chemical wastes, or mixtures of the two, based on the commonality of risk to a member of the general public becoming inadvertently exposed to such a hazard.

With ORNL Chairmanship and NCRP secretariat, the technical committee includes university and industry representatives. Given the societal requirement that all waste must be properly managed, and using an appropriate hierarchical system of public protection (and cost), the reader is taken through the process of development of a common connection, via risk, of wastes generally; from 'exempt' waste through 'low-hazard' to 'high-hazard', each with its derivation and assessment of 'risk index' and relevant potential exposure scenarios.

Consequent to this proposition, the present classifications of radioactive, plus that of some hazardous chemical and mixed wastes would not be greatly modified, except by current statutory or 'list' issues not directly related to risk. Adoption of this common waste classification would see wastes of negligible public risk reclassified 'exempt', thus acceptable for municipal/industrial landfill; those of acceptable risk classified 'low hazard' requiring dedicated 'near surface' facilities, with most currently classified high level radioactive wastes, and high hazard chemical wastes destined for geological repositories or high isolation facilities.

In short, a well-presented response to a growing national and international issue.

Roger Aslop
JBS Health Physics Pty Ltd
Mascot NSW

Front cover images courtesy of
Dr. Trevor Smith, Photophysics & Photochemistry Group,
University of Melbourne, VIC.

The coloured image inset shows a fluorescent lifetime map of ethidium bromide and nile red stained onion skin, imaged using the green output of a Coherent Innova ion pumped Mira Ti:S femtosecond oscillator, seeded RegA 9000 regenerative amplifier pumped OPA 9450 optical parametric amplifier (OPA) system, operating at 250 kHz.

The different colours are indicative of different fluorescence lifetimes measured across the onion skin structure. Time-resolved fluorescence decay curves can also be measured by time correlated single photon counting (TCSPC) using the same ultrafast laser system.

The use of the femtosecond Ti:S oscillator, synchronously pumped OPO, regenerative amplifier and OPA combination allows Dr. Smith's group flexibility in the various time-resolved fluorescence imaging modes using time-gated wide field measurements or scanning confocal and/or two photon operation. The system also provides access to a very broad selection of excitation wavelengths enabling the study of a wide range of fluorescent chromophores important in biomedical imaging, luminescent polymers and quantum dot photoemission.

Background image shows Dr. Smith's laboratory where these images were collected and the Coherent ultrafast laser system used.

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