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The subject matter of this month's front cover is astronomy at the South Pole. John Storey UNSW, Jean Vermin University of Nice and Michael Ashley UNSW are at the ceremonial South Pole during a visit to set up a series of balloon flights to measure the suitability of the site for astronomy. Astronomers from UNSW also installed an infrared sky brightness monitor, IRPS, which has demonstrated that the winter sky at the pole is a hundred times darker than at other terrestrial observatory sites, at a wavelength of 2.35 micron. This paves the way for a new generation of ultra sensitive astronomical observations from Antarctica. Photo supplied by Professor JWS Storey Physics UNSW.
Innovate or Stagnate??

Innovation is the theme of the month. The Prime Minister describes it simply as new ideas, new inventions and new commercialisation coupled with new ways to do things. The Government, after much hype, introduces an Innovation Statement which is not only going to answer Australia’s unemployment problems, but, by a magical sweep of the accountant’s wand, is also going to produce an excess of funding which might reduce our balance of payments.

More likely in an election year, any surplus will be used to fund election promises in marginal seats. It was pointed out in a following news article tonight that the ‘ethnic’ vote could prove important in marginal and near-marginal seats. Is, then, the Innovation Statement an attempt to woo the vote of scientists, engineers, medico’s and other technologists in seats where the science and technology lobby has the potential to command a swinging electorate?

I think not, and I suspect no-one else will see this as a possibility. Businessmen apparently see the Innovation Statement as good for business and essentially ignore the science and technology opportunities. Scientists ignore the proper focus on restoring industry confidence and the provision of science and technology support for industry. Each group sees the opportunities for itself in the statement and tends to ignore the possible cross-disciplinary opportunities provided.

Science gains a set of Major National Facilities, primarily in and to expansion of our astronomy support. We gain a genome mapping facility and a high flying aircraft for exploration purposes. We hear Senator Cook interviewed and strain the level of believability as he attempts to explain how the development of our skills in astronomical instrumentation will expand the base of our Small-to-Medium Enterprises (turnover $1m-$50m) and hence reduce our unemployment while expanding our exports.

My dictionary suggests that innovation, simply defined, is the “bringing in of novelties, making changes” (from the Latin novus - new). If we are to respond to an Innovation Statement, then we as physicists must innovate within our profession, as well as become innovators. We must look within our research to determine what might bring value to the outcomes. Can we develop our basic research outcomes or can we adapt our basic research techniques and processes to help industry, small and large?

There are physicists in industry who are making significant contributions to their companies. Physicists are actively involved in developing new techniques for diagnosis and treatment in health areas. Physicists can certainly make major contributions to our understanding of our environment. We can contribute very positively to high technology areas in small industries. We can also do very good physics.

In a recent column I suggested we should examine the focus of our training to alter the perception of some (including many students) that the only true physicist had a PhD and studied vaguely understandable processes in high technology laboratories. Should we instead concentrate on the model which views a physicist as someone completing a first degree who is well prepared to make significant contributions to our society?

I continue this line of thought, with the idea that we as physicists must dispel the attitude that an applied physicist is not a ‘true’ physicist – we must also dispel the idea that an applied physicist is a failed engineer. Physicists must prove their worth to the business community – mathematicians have done this with their ‘mathematics-in-industry’ workshops. Why shouldn’t we do something similar? We could invite our local small industries to present a group with problems to which a physicist could apply his/her training to produce a solution. Small projects could lead to bigger involvement. Many physicists would enjoy the problem, because physicists are, amongst other things, problem solvers.

On behalf of the Executive, may I wish all members of the AIP and NZIP a very Merry Christmas and pass to you the hope that the New Year will begin the long awaited upsurge in society’s appreciation of the contribution of physics and physicists.
EDITORIAL

VALE 1995

Christmas again. When I was a boy it took forever to arrive, now it seems no time at all since the last one. Perhaps it is a time dilation, related to the fact that my average velocity then was much greater than it is now. We thought we would join in the general seasonal festivities by presenting on this month's cover not one but three Fathers Christmas, appropriately for Australia, at the South Pole, with snow for those with feelings of nostalgia for a white Christmas.

With a Federal election looming the general enjoyment is marred to some extent by political pressure groups battering each other over the head with meaningless statistics. An odd paradox isn't it, that with an apparently declining respect for science, numbers and simple formulae are coming into more prominence in public argument. Perhaps it isn't so strange after all. The use of science and mathematics by people whose only aim is to find apparent support for their dogmas and who lack the integrity needed for effective work in these fields, will diminish the public's regard for science. Every Australian knows that "If you lie down with dogs you get up with fleas".

To quote just one such ludicrous example, the current per-capita-income league table places us 22nd in the world and is hence the subject of numerous media economic disaster stories. There may be sillier ways of measuring social or economic well-being than converting the income of a country to US dollars and dividing by the number of people in the country but if there is I haven't seen it. A physicist would immediately question the validity of this method, merely from the ridiculous rankings it produces. The price of the necessities of life vary wildly between countries, exchange rate fluctuations, the hours worked to gain the income, and other relevant parameters are all neglected in this long division statistic. The Business Council of Australia loudly trumpets the virtues of this simple minded scheme. Let us hope they are doing it for political reasons. If they really believe it, our dismal record on commercial R&D and foreign takeovers is likely to get worse.

So the good news is that we nationally are better off than simplistic economic pessimists would have us believe. We have also, so far, escaped some of the more ridiculous assaults on science and technology tried in other countries. Britain had a serious scheme to sell off the Patent Office, which I believe and hope, has been stopped. When I heard of it I was reminded of legislation by a former NSW State Government to allow used car salesmen to "self regulate" their industry. A sufficient number of voters knew about car salesmen to have this stopped. Do a sufficient number of people know what a Patent Office does, so that they would take appropriate action if ours comes up for sale after all the airports and other real estate items are flogged off?

I am opposed to pointless name changes but have sometimes considered them the lesser of several evils. Most new heads of large organisations feel compelled to immediately publicly demonstrate their power and authority. Changing the name is a fairly harmless way of allowing them to do so. The cost of new letterheads and re-carving the organisation's title on the building is frequently small compared with the turmoil produced by the more serious structural changes which may ensue if the new head is prevented from ego bolstering in this visible but superficial way.

The US National Bureau of Standards was renamed in 1988 to become the National Institute of Standards and Technology, a pointless but apparently harmless change. NIST is in the US Department of Commerce, which is now under political financial attack. The US physics community is seriously worried that the maintenance of standards and the basic research on which they depend, will suffer. Support for NIST in Congress is likely to be less because many members are not clear about its function under its new name. In the new year we should perhaps be more careful about name changes. They may be pointless but they may not be harmless.

Merry Christmas, a Happy New Year and may all your grants be substantial.

Jak Kelly
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Forty-Five Years of Astronomy at the University of Canterbury

Dear Editor,

Although the content of the article in question makes its intended scope clear, the choice of the title, "Thirty Years of New Zealand Research in Astronomy", for the paper by John Hearnshaw in the September issue of the Physicist, may come as a shock to your readers with the implication that this history is limited to three decades. During the period 1950-65 the University of Canterbury (previously Canterbury University College) was, in fact, a world-leading centre in certain areas of astronomical research.

In 1950 Clif Ellyett returned to Christchurch with a fresh PhD from the University of Manchester (Jodrell Bank), and set up a team to conduct radar studies of meteors. Over the subsequent decade and a half that team - including Walter Roth, Bob Bennett (still working on radar meteor research at Canterbury), and Colin Keay (the book review editor of this journal) - produced some dozens of publications, and trained many research students: 16 theses were produced in that period, a remarkable achievement in the days when most able undergraduates left to obtain their research training overseas. This research was pioneering in terms of its astronomical implications: the controlled radar meteor rate monitoring program in the early 1960s remains the only such southern hemisphere data set, providing vital information regarding the seasonal and diurnal variations in meteoroid influx, the associated publications still being cited many times each year. The program also had practical implications, for example in assessing the impact hazard to spacecraft as the space age began, so that the team received funding from NASA and the US Air Force to assist in their investigations. Regarding the founding of Mount John University Observatory, it was through Ellyett's initiative (aided by Frank Bateson) that Canterbury became involved in optical astronomy. After Ellyett and Keay left for the University of Newcastle in 1964/65, the radar meteor research continued under the direction of Jack Baggaley, assisted by Bennett.

Of course professional astronomy in New Zealand began even earlier, with the Carter Observatory in Wellington having been opened in 1941. There is a longer tradition of amateur and Maori astronomy. Unless some other claimant comes forward, it would seem that the radar meteor work in Canterbury was the first astronomical research conducted at any New Zealand university. I have in the past claimed that the meteor program at the University of Adelaide could claim the same title within Australia, but it appears that some solar radio astronomy was pursued at the University of Western Australia in 1946-48 (The Australian Physicist 13 (1976) 20). The radar meteor work in Adelaide began around 1950, again with a Jodrell Bank influence: when Leonard Huxley arrived to take up the chair of physics, he did so with Bernard Lovell's urging to set up a southern hemisphere counterpart to his own team. Thus the radar meteor groups in Christchurch and Adelaide will, in the year 2000, both celebrate remarkable half-centuries of continuous innovative and world-leading research.

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Diminishing Prospects in Research

Dear Editor,

I read John Innis’ article (May 95) with much interest, having been a student colleague of John in the early 80s. Since then we have kept in touch occasionally, and met most recently at the AIP Congress in Brisbane in 1994. Although his article raised many issues which I could elaborate on, I wish to concentrate on John’s commentary on, “the main topic of conversation at the 1994 AIP Congress...jobs”.

I can confirm that “jobs” and “future options” were much discussed by many people of our vintage. However, it was only months later, when discussing the same issue with John, who made the comment that “they (whosoever ‘they’ are), have taken away our dreams”, did I realise the full impact of what has happened. The last time I actually considered what my long term scientific goals were was over 3 years ago. I had become so focussed on finding a future in physics, that my initial motivation for embarking on a research path in physics (ie, the satisfaction involved in discovering how nature works) had been lost.

The most regrettable aspect of this “loss” for the physics community at large and the science community in general, is that I am only one of a quickly growing number of “thirty-something” physics (science) graduates for whom this is true. No one can accept responsibility for this “loss”, nor do I know who should, but the one thing I am certain of is that it can not lead to a vibrant scientific community. If indeed there are very few current or future jobs then our potential future researchers need to be made painfully aware that, with an ever increasing number of PhD graduates in physics, the probability of obtaining a research career in physics is constantly diminishing.

Having said this, I know that even if all the arguments against following a career in physics had been presented to me when I was an undergraduate, I probably would have chosen it. Maybe, that’s as it should be.

For the record, after six years post PhD, two 3 year post docs, I am no longer directly involved in physics research.

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Recently while going through some of the papers of my father, Jack Rayner (1906-1982), I came across several songs which I believe were sung originally at the Cavendish Laboratory and subsequently found their way to the University of Sydney. Having enjoyed them both for their clever humour and their commentary upon the state of physics at the time, I thought that they may be of interest to readers of this journal.

My father was a physics student at Sydney from 1925 to 1928 graduating with first class honours in 1929. For his honours project he worked in A/Prof Vic Bailey’s group carrying out Townsend electron swarm experiments on the capture of electrons by molecules. Subsequently he joined the NSW Mines Department as a trainee geophysicist and participated in the work of the Imperial Geophysical Experimental Survey.

IONS MINE

**Tune: "Clementine"

1. In the dusty lab’ratory
   ‘Mid the coils and wax and twine,
   There the atoms in their glory ionise and recombine.

*Chorus:*

Oh my darlings! Oh my darlings!
Oh my darling ions mine!
You are lost and gone for ever
When just once you recombine!

2. In a tube quite electrodeless,
   They discharge around a line,
   And the glow they leave behind them
   Is quite curking for a time.

3. And with quite a small expansion,
   1:0 or 1:9,
   You can get a cloud delightful,
   Which explains both snow and rain.

4. In the weird magnetic circuit
   See how lovingly they twine,
   As each ion describes a spiral
   Round its own magnetic line.

5. Ultra-violet radiation
   From the arc or glowing line,
   Soon discharges a conductor
   If it’s charged with minus sign.

6. Alpha-rays from radium bromide
   Cause a zinc-blende screen to shine,
   Set it glowing, clearly showing
   Scintillations all the time.

From conversations I had with my father it appears that physics songs were extremely popular within the Physics Department in the mid 1920’s and were performed with great gusto at departmental smoking evenings. The University, as he recalled it, must have been quite a lively place at the time with the students electing a horse to the University’s Senate. They also expressed their displeasure with the Vice Chancellor of the day by printing several thousand additional invitations to a formal dinner hosted by the VC; the invitations being liberally distributed in down-town Sydney to anyone who wanted one.

The songs in my father’s papers are likely to have been brought to Sydney from the Cavendish Laboratory by Henry Briggs. Briggs was educated at Sydney, and was a lecturer in the Physics Department from 1916 to 1928 and associate professor through to 1939 [1]. During this time he studied at the Cavendish Laboratory, receiving his PhD in 1926. The likely date of his return therefore overlaps neatly with that of my father who would have been in third year physics in 1927. At this time Briggs was interested in the velocities of α-particles emitted from Radium C and published several papers in the area [1].

It is interesting to note from the black body radiation song “hν” that while physicists at that time seemed to be quite comfortable with the “old quantum theory”, there appeared to be great distrust of the new quantum mechanics which must have been just emerging, as evidenced by the sentiments expressed in the last verse. The reference to interference in the second last verse also indicates that the issue of wave-particle duality was far from settled – if it ever will be!

At the recently concluded XXVI International Physics Olympiad held in Canberra, “hν” was revived with great enthusiasm at the closing banquet by the team of examiners to the obvious delight of the international audience of young physicists. Judging by the number of requests for copies of the words it could well become a world-wide hit.

I trust that readers of the Physicist will derive much pleasure from these songs from the golden age of physics.

**“hν”**

*Tune: “Men of Harlech”*

1. All black body radiations,
   All the spectrum variations,
   All atomic oscillations
   Vary as “hν”.

*Chorus:*

Here’s the right relation
Governs radiation.
Here’s the new,
And only true.
Electrodynamic equation;
Never mind your
\((d\phi/dt)^2\), Ve, or \(1/2 \mu m v^2\)
(If you watch the factor “c^2”)
“E” equal to “hν”.

2. Ultraviolet vibrations,
   X and gamma ray pulsations,
   Ordinary light sensations
   All obey “hν”.

3. Even in matters calorific,
   Such things as the heat specific
   Yield to treatment scientific
   If you use “hν”.

4. In all questions energetic,
   Whether static or kinetic,
   Or electric, or magnetic,
   You must use “hν”.

5. There would be a mighty clearance,
   We should all be Planck’s adherents,
   Were it not that interference
   Still defies “hν”.

6. Intellectual contortions
   Matrices and wave abstractions
   Now conspire in all proportions
   To confound “hν”.

*Chorus:*

But we’ve got the unction
That the proper function
Still remains in all domains,
Where we consider motion
Never mind your
\((d\phi/dt)^2\), Ve, or \(1/2 \mu m v^2\)
(If you watch the factor “c^2”)
“E” equal to “hν”.


John Rayner
Electronics Engineering and Applied Physics
University of Canberra
Physics is seen by many as an intimidating subject, and traditional methods of teaching the subject often do nothing to dispel this notion. This perception of difficulty is usually associated with the mathematical formalism used to describe physical phenomena. Physics is very often taught as if it is nothing more than applied mathematics and many students, taught in this way, have little appreciation of the meaning of their calculations and methods.

The theory of quantum electrodynamics (QED) describes the interaction between light and charged particles. It predicts results which are in agreement with experiment to extraordinary accuracy. This predictive power comes from the powerful and complex mathematical methods of the theory. This marriage of quantum mechanics and electromagnetism, perhaps more than any other area of physics, might be expected to remain the exclusive domain of specialists, only those who are familiar with the necessary complex mathematical formalism.

Fortunately for us, however, QED has been spared this fate. In a very large part this has been due to Richard Feynman, and his popular book “QED: The Strange Theory of Light and Matter,” (Princeton University Press 1985), which presents an extremely readable account of QED aimed at a general audience. The book is based on The Alix G. Mautner Memorial Lectures delivered at UCLA by Feynman in 1983.

Alix Mautner, the wife of Feynman’s long time friend Leonard Mautner, had always expressed an interest in hearing a clear non-technical explanation of QED. And so Feynman prepared such a set of lectures on the subject, but as he admits on the first page of the book, was sufficiently unsure of this venture that he did not wish to try the lectures out at his native Caltech. Instead, he first delivered the lectures far away from California, choosing remote New Zealand as his testing ground, and in the process giving the New Zealand Physics Community the rather dubious honour of being the guinea-pigs for his QED Lectures. At Auckland University, these lectures were delivered in 1979, as the Sir Douglas Robb Lectures. They were tremendously successful, “at least for New Zealand,” as Feynman adds. So Feynman returned to Caltech with confidence in the accessibility of his QED lectures, and...
appropriately, after Alix Mautner's death, chose to honour her memory by delivering again the lectures which he originally wrote for her.

Richard Feynman delivered the Sir Douglas Robb lectures at Auckland University in July and August of 1979. There were four one hour lectures.

The lectures were videotaped, and the original tapes have been stored at the Auckland University Physics Department ever since. Although the lectures have occasionally been viewed by enthusiastic students, they have been little used in either undergraduate or graduate teaching. In our opinion, this was a shame, because the Auckland QED lectures are not only a unique and interesting part of New Zealand's physics history but provide an excellent, non-technical introduction to one of the most difficult areas of physics. So, beginning in the 1994 summer vacation, we set out to re-examine the lectures.

We felt that the Feynman tapes had been sitting gathering dust for long enough and a revival of the lectures was long overdue. We wanted to remind the New Zealand physics community of an important historical event and to use the lectures more formally in undergraduate and graduate teaching. Feynman's approach to physics teaching is unconventional, and in some respects requires a more mature and sophisticated approach from students than does a more traditional approach. It is important that a physics education presents students with the idea that there may be more than just one way to explain a particular physical phenomenon, and we thought that the tapes of Feynman's lectures could be complementary to standard lecture courses.

Because of their historical importance, we wanted to review and inspect the original video tapes and produce additional archival copies. Not trusting solely to a video archive, we also wanted to produce a written transcript of the tapes as a textual archive. We considered it important to preserve as complete a record of these lectures as possible.

As part of this archival process, we also wanted to compare the Auckland lectures with those delivered three years later at UCLA, and eventually published in *QED - The Strange Theory of Light and Matter*. We were primarily interested in seeing how Feynman had modified his presentation in the intervening three years and to see if there were any significant differences.

## The Feynman Lectures at Auckland

The lectures were recorded on U-MATIC video tape, which at the time provided some of the best quality video reproduction available. Even though the tapes are now over 15 years old, they have shown little sign of deterioration and the video quality is generally good. The soundtrack quality, however, is patchy. This is not a consequence of the age of the tapes, but rather of the use of an unsatisfactory sound recording system at the time of the lectures. Feynman's broad accent at times makes listening difficult. These problems aside, however, the lectures can be viewed and listened to very comfortably.

Having made a new video archive of the original tapes, and after re-reading the published "QED - The Strange Theory of Light and Matter", we began to seriously examine the tapes of the Auckland QED lectures. Almost from the opening sentences, it became clear that there were essentially no significant differences between the approach and explanation Feynman used in Auckland, and that which he used years later at UCLA. Of course there were some minor differences, but the order of presentation, and the examples used, differ little. The contents of each of the four lectures correspond very closely to each of the four chapters in the published book, although the lecture titles do vary slightly from the chapter titles. The four lectures delivered at Auckland are summarised briefly below.

### Lecture 1 - Photons: Corpuscles of Light

Delivered on 31 July 1979. Feynman begins with a historical discussion of the theory of QED. He stresses the accuracy of the theory, pointing out the precision to which it predicts the value of the magnetic moment of the electron. He explains that the accuracy ...

### Lecture 2 - Fits of Reflection and Transmission: Quantum Behaviour

Delivered on 2 August 1979. His lecture continues the discussion of partial reflection from Lecture 1. But the treatment rapidly becomes more sophisticated, as Feynman illustrates the ideas of Lecture 1 by presenting a "sum over paths" analysis of reflection from a plane mirror to derive the familiar law of reflection. His discussion of the diffraction grating and lenses extends these ideas even further, providing beautiful examples of the elegance of his approach to explain familiar effects. He summarises the idea of the probability amplitude in QED, and for those who have studied mathematics at university, he identifies these amplitudes as complex numbers. Lecture 2 concludes with a brief, but succinct, discussion of the physical origin of reflection from a glass surface.

"What reflection really is, is that light goes down, is absorbed by something which shakes ... and that emits a new light which comes back. Reflected light is really not the same photon coming back as went in. Photons from the source went into the glass, and from the glass comes out a new photon. This is an interesting thing, that makes light in the end simpler and simpler and simpler."

### Lecture 3 - Electrons and their interactions

Delivered on 7 August 1979. Feynman introduces space-time diagrams, and uses these to describe the trajectories of electrons and photons as they travel in space and time. The junctions on space-time diagrams where the trajectories of
photonson and electrons intersect are identified as very
significant, and the probability amplitude associated with
the junction is a very important number which in 1979 was known as I/137.03590(3). As Feynman says:

"That's a magical number, a mysterious number. Good
theoretical physicists put at the top of their bed at night, and
dream and dream if they can figure out why that's the right
number."

To illustrate the use of these diagrams, and the general methods
of QED, Feynman follows two electrons travelling between
two points in space and time. Although the principles of
calculation are simple, the calculations rapidly get complex if
one considers the possibilities of one or more photons being
exchanged en route. Complex, but nonetheless possible,
especially with computers to carry out the calculations. And it
is because these calculations are possible, that QED has been
able to explain atomic structure, and with it most of the
macroscopically observable aspects of the world.

Lecture 4
New Querie

Delivered on 9 August 1979. Although this is the final lecture,
it is far from being just a summary of what has gone before.
Feynman begins by discussing the problems of QED, and in
particular renormalisation. He describes it as "... a dippy way
to do mathematics," but one which he justifies by its success,
"... we do know, that if we do it this dippy way, we get results
that agree with experiment." He concludes by considering the
connection between QED and the rest of physics — the
nucleus, and the standard model. He discusses the search for
a unification of physics, but mentions the difficulties inherent
in including gravitation in a unified model.

Question Time

We were pleasantly surprised to see the questions retained in
the video tapes, and these represent one point which
significantly differentiates the Auckland lectures from the
published QED - The Strange Theory of Light and Matter.
They also provide some delightful moments. For example, at
the end of Lecture 1, Feynman is asked whether he likes a
picture of the world based on probability. He replies:

"... I never think 'This is what I like, this is what I don't like'.
I think, 'This is what it is, and this is what it isn't.' Okay? And
whether I like it or I don't like it is really irrelevant, and
believe it or not, I have extracted it out of my mind."

Another from the same lecture is worth recording in full here,
illustrating Feynman's well known intolerance of woolly
philosophy and philosophers. When asked:

"When you are looking at something, do you see only light, or
do you see the object?"

He replies: "The question of whether or not when you see
something, you see only the light or you see the thing you're
looking at, is one of those dopy philosophical things that an
ordinary person has no difficulty with. Even the most
profound philosopher, who's been sitting eating his dinner,
hasn't any difficulty in making out what he looks at
perhaps might be only the light from the steak, but it still
implies the existence of the steak which he's able to lift by the
fork to his mouth. The philosophers that were unable to make
that analysis on that idea, have fallen by the wayside through
hunger."

Wonderfully succinct, even in print, but it is watching
Feynman deliver this humourous response which really
illustrates his opinions on such matters!

Given the New Zealand context of the lectures, Feynman does
make occasional references to his hosts. These are not always
complimentary, however. Many visitors to New Zealand
express surprise at how New Zealanders always appear to
spend a surprisingly large amount of time in negative self-
criticism, and Feynman was no exception:

"You know ... I've only been here a few days, and everybody's
talking themselves down. I thought this would be a happy
country, but something's happened to you. You've got plenty
of room, and not too many people, and it looks like it ought to
be good."

Feynman, however, does point out that we have some things to
be proud of, and while discussing the history of atomic
physics, consoles us with the advice: "... don't forget, you had
Rutherford, so it's okay."

The QED Lectures For Teaching

Our primary aim was to see how the tapes of Feynman's
lectures at Auckland could be used in teaching undergraduate
and graduate physics. Watching the Auckland lectures, it was
evident from the first, that Feynman's lectures are very visual
and heavily diagrammatic, and it is obvious that simply
reading the text without his diagrams is pointless and indeed,
even misleading. The published version of "QED - The
Strange Theory of Light and Matter" contains the diagrams
that Feynman used in his lectures. But it is, by far, preferable
to view Feynman delivering the lectures himself. Although
they are, like all lectures, a little less structured and organised
than an edited transcript, the advantages of seeing Feynman's
enthusiasm for his subject far outweigh any objections on the
grounds that there are slight inconsistencies in his delivery. In
any case, the published version of "QED - The Strange Theory
of Light and Matter" was carefully edited for consistency and
accuracy by Feynman and his good friend Ralph Leighton, and
provides a definitive reference to which one can refer if
necessary.

We have shown the videos to second and third year classes in
the second semester of this year, and they have proven very
popular, with many staff turning up as well. We feel that the
material in the lectures is more appropriate for second and
third year classes, because Feynman's "arrow algebra" is better
appreciated by students who are familiar with complex
numbers. The lectures were open to all interested students, and
not just to students studying quantum mechanics and optics.
We feel that his approach is valuable to all serious students of
physics.

Since Feynman delivered the QED lectures, much progress has
of course been made in the fields of nuclear and particle
physics, and some of what Feynman says in Lecture 4 is now
slightly dated. In particular, the t-quark, undiscovered at the
time of the lectures, now, in 1995, appears to have finally been
observed at Fermilab. But in 1979 Feynman could only discuss
it as a particle existing in theory. Considering his discussion in
an historical context provides a valuable lesson for students,
and can lead to a discussion of the success of the Standard
Model during the second half of this century. It also illustrates

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very clearly the difficulties in high-energy physics, and the long delays between theoretical predictions and experimental verification.

Conclusions

It is hoped that this study of Feynman's 1979 lectures on QED will lead to their increased use as a teaching aid in graduate and undergraduate courses at the University of Auckland. Students should benefit from Feynman's style of presentation, and his success in making a very difficult subject accessible without great mathematical complexity. The QED lectures provide an object lesson to all physics teachers.

Watching Feynman can teach us a lot, not only about QED, but also about how to approach the teaching of difficult subjects in physics. Feynman outlines the methods of calculation in QED without confusing the audience with great quantities of mathematical formalism, but he is refreshingly honest when he states that they appear strange and uncomfortable at times.

He shows us that it is not necessary to disguise physics as only mathematical calculations, but neither is it necessary to compromise and dilute the subject matter so that it bears little resemblance to reality, or has little relation to the methods of practising physicists.

Acknowledgements

We would like to acknowledge the cooperation of Ralph Leighton, Princeton University Press and the Estate of Richard Feynman in carrying out this work. Financial assistance was provided from a University of Auckland Faculty of Science Summer Scholarship and the University of Auckland Higher Education Research Office.

VHS Video cassette copies of the 1979 Robb Lectures at Auckland University are available, on a non-profit basis, for the price of NZS50.00 plus postage and handling.

For enquiries regarding cassette availability or for any further information, please contact the authors at the University of Auckland or via email: qedtapes@phy.auckland.ac.nz.

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Get your advertisement for an available position to the very physicists looking for employment. A valuable fast and directed avenue to publicise not only
Dr. Yukatoh Proves that Cats Don't Have Wave Functions.
Once and for All, the Problem of Schrödinger's Cat.
The theory of X-ray diffraction is well established. Redistribution of electron density due to deformation of chemical bonds in the solid state can be observed directly today. High precision diffraction imaging is a powerful tool for understanding the chemical bonds as well as physical properties related to the electron density.

Introduction

In the decade following the discovery of X-rays in 1895 by Röntgen, experiments were carried out to determine the nature of the radiation. Diffraction by a narrow slit was observed leading to an estimated wavelength of 10^{-8} cm (1Å). The use of crystalline copper sulphate, as a natural diffraction grating was demonstrated by Friedrich, Knipping & von Laue in 1912 [1]. The ionisation spectrometer was developed shortly afterwards. Improved experimental techniques due to WH and WL Bragg [2] contributed significantly to the use of X-rays as a probe to study the internal structure of crystals at the atomic level.

Crystallography continually thrived through rapid application of new developments. With the widespread use of quantum counters in diffraction work, the word diffractometer was adopted in 1952 by the Apparatus Commission of the International Union of Crystallography to describe instruments for measuring diffracted X-rays [3]. The word spectrometer was reserved for instruments with the principal function of investigating X-ray wavelengths or neutron energy spectra.

Techniques involving elastic and inelastic scattering of X-rays have been limited essentially by the strength of radiation sources. The first dedicated sources of synchrotron radiation came into operation in the early 1980’s. Spatially periodic arrays of magnets were installed and tested on linear accelerators as early as 1953 [4]. A new generation of synchrotron sources using such arrays is now coming into action. This advent of high brilliance, high energy, synchrotron radiation provides a wide range of new experimental possibilities. Extremely small single crystals can be used for intensity measurements using synchrotron radiation. In an exploratory study on an 800 μm³ crystal of a zeolite by Eisenberger and coworkers [5], the information content in weak reflections increased dramatically.

One-Electron Density

The electron density is a probability function per unit volume of finding an electron in a volume d r at point r, independent of spin. The one-electron density function [6] is defined as:

\[ \rho(r) = N \int |\Psi(r_1, r_2, ...)\|^2 d\tau_1 d\tau_2 ... d\tau_N \]

where the wavefunction \( \Psi(r_1, r_2, ...) \), which depends on 3N space and N spin coordinates, defines the electron distribution uniquely.

The density \( \rho(r) \) reflects the characteristics of the orbital wavefunction for an electron. As a fermion, the total electron wavefunction is antisymmetric, i.e., changes sign if two electrons are exchanged. If antisymmetry occurs in the one-electron density function, the spin function must be symmetric. Conversely, if the orbital wavefunction for an electron is symmetric, the spin wavefunction would be antisymmetric.

The atomic electron density \( \rho \) may be calculated in various ways. Spherically averaged atomic density derived by Cromer & Mann [7] from Hartree-Fock wave functions are widely used. The one-electron density function, \( \rho(r) \), is related to the structure factor \( F(s) \) by

\[ F(s) = \int \rho(r) e^{2\pi i s \cdot r} d^3r \]

[8]. The \( F(s) \) are just the Fourier components of \( \rho(r) \).

For an adiabatic electronic wavefunction, \( \rho(r) \) or \( F(s) \) depends parametrically on the nuclear coordinates, \( R_n \). For a crystalline material where the electron density is periodic, the coherent elastic scattering power is non-zero only at a set of discrete points which define a reciprocal lattice. Fourier decomposition enables the unit cell electron density to be written as:

\[ \rho(r) = \sum_{h} \sum_{k} \sum_{l} \ |F(h)|^2 e^{2\pi i (h \cdot R + k \cdot b^* + l \cdot c^*)} \]

where the summation extending over all reciprocal lattice points \( h = (h, k, l) \). \( F(h) \) is the structure factor for the scattering vector \( s \) where

\[ s = h \cdot a^* + k \cdot b^* + l \cdot c^* \]

being reciprocal lattice vectors which describe the cell in reciprocal space.

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In practice, the Fourier summation does not extend over an infinite range. The resulting restrictions on |s| are discussed by Hoppe & Mason [9]. The maximum value of |s| is restricted to 2A by the wavelength \( \lambda \) of the radiation. \( s = 0 \) is not accessible since it corresponds to forward scattering which interferes with the incident beam. In the absence of dispersion, \( F(000) \) is the number of electrons in the unit cell.

The Kinematic Theory of X-Ray Diffraction

In principle it is possible to determine the one electron density from single crystal X-ray diffraction experiments. This requires precise measurement of diffracted intensities under kinematic scattering conditions. The kinematic theory of X-ray diffraction assumes the interaction between the incident beam and a particle to be elastic so that the wavelength is unperturbed. It also assumes that the X-rays deviate no more than once in the crystal. If the incident and diffracted wave-vectors are denoted \( \mathbf{k}_i \) and \( \mathbf{k}_f \) respectively the diffraction vector \( s \) is given by

\[
\mathbf{s} = \mathbf{k} - \mathbf{k}_0 = (\mathbf{u} - \mathbf{u}_0) / \lambda
\]

where

\[ |s| = 2 \sin \theta / \lambda \]

\( \mathbf{u}_0 \) and \( \mathbf{u} \) are unit vectors. The vector \( s \) plays a fundamental role in scattering theory because the scattered intensity depends explicitly on its magnitude.

The elastically scattered X-ray intensity is proportional to [10]

\[
I_{\text{XR}} \propto I(\mathbf{s}) |F(\mathbf{s})|^2
\]

[10], where \( I_{\text{XR}} \) is the Thomson cross section for a free electron. \( F(\mathbf{s}) \) is the familiar molecular form factor or, for a crystal, the structure factor. The integrated intensity measured in diffraction experiments contains no information on phases.

The quantity derived from the measured diffraction intensity after corrections and data reduction is the structure factor amplitude \( |F(h)| \), which is used to derive an image of the one-electron density, from which the crystal structure can be determined. That structure provides a great deal of useful information.

Given the accuracy with which many experiments can now be performed, the electron density distribution can often be determined accurately also.
Difference Density

Plots of \( \rho(r) \) are graphical representations of atoms in which the perturbations due to chemical bonding are relatively small. These perturbations are best illustrated by comparing the experimentally derived density with a model density. Evaluation of a \( \Delta \rho \) synthesis was originally suggested as a mean for correcting parameter errors in the model during refinement [11, 12].

Theoretically the difference density \( \Delta \rho (r) \) is evaluated from \( \rho - \rho_{\text{mod}} \) where \( \rho_{\text{mod}} \) is a model representing the true structure. The deformation density function \( \Delta \rho \) is defined as:

\[
\Delta \rho (r) = \sum_{hkl} \Delta F(h) e^{2\pi i h \cdot r} - \sum_{hkl} F_{\text{mod}} e^{2\pi i h \cdot r}
\]

where \( \Delta F(h) = F_{\text{obs}} - F_{\text{calc}} \) for the approximately phased scattering factor amplitudes. The model most often employed to calculate \( F_{\text{calc}} \) assumes spherically symmetric ground state atoms located at the positions determined from refinement. It was proposed as a method for displaying the redistribution of electrons due to bonding by Cochran [13].

Measurements of the total density are affected seriously by experimental truncation of the Fourier series. As the redistribution of charge due to chemical bonding contributes most strongly to the low angle reflections, the effects of series truncation on \( \Delta \rho \) measurements are less serious. The sharper components of the true \( \Delta \rho \) are predominantly those associated with anharmonic thermal motion. Series truncation also reduces the magnitudes of features due to lone pairs, by amounts which increase with the effective nuclear charge.

Difference density is usually contoured with smooth lines traced through points of constant density in two dimensions. The type of line drawn depends on whether regions of positive or negative density are depicted. Solid lines represent accumulation of electrons (positive \( \Delta \rho \)), and dashed lines, negative \( \Delta \rho \). Peaks and troughs disposed throughout a difference density map represent regions of electron excess and deficiency respectively.

The contribution of electron density to the energy is influenced by the electrostatic potential, whereas its contribution to forces at the nuclei are determined by the potential gradient. The topological features in \( \Delta \rho \) maps are influenced by polarising terms due to the Coulomb potentials of local charges, being affected significantly by the requirements of exchange, which gives rise to the Pauli exclusion principle. Its pertinence to chemical bonding makes the \( \Delta \rho \) information especially valuable. Redistribution of electron density due to deformation of chemical bonds (ionic, covalent or metallic) in the solid state can be observed directly.

The physical properties of materials are also constrained intrinsically by the structure factor moduli. Electrostatic properties can also be extracted from accurate diffraction data [14]. The evaluation of diamagnetic susceptibility from measured \( \Delta \rho \) was studied by Hester [15]. Electrostatic potential, electric field, and electric field gradient are also related to the electron and nuclear charge densities. The relationship of ferroelectricity to the electron density was derived by Hsu, Maslen & Ishizawa [16].

Reliability of \( \Delta \rho \) Image

Reliable measurement of \( \Delta \rho \) maps requires high accuracy in all the accessible structure factors. The reliability of modern results using synchrotron radiation is sufficient, being consistent within and between high precision structure analyses. The atomic sites for Y1 and Y2 in Y2BaCuO4 have similar geometries [17] but are crystallographically independent. The similarity between \( \Delta \rho \) topographies for the Y1 and Y2 maps is an indicator that tests reliability. Sections of \( \Delta \rho \) perpendicular to the (010) plane passing through the Y—O bonds for Y1O7 and Y2O7 are shown in Figure 1. The diagrams show

2 Difference density for the Nb atom in LiNbO3, and for the Ta atom in LiTaO3. Map borders 4.4 Å by 4.4 Å, contour intervals 0.5 eÅ⁻³, positive, negative contours — solid, dashes respectively.
degree of correspondence is such as to encourage the view that current techniques for imaging the $\Delta p$ maps are reliable.

The compounds LiNbO$_3$ and LiTaO$_3$ are iso-structural, and have similar ferroelectric properties. Concordant analyses of the $\Delta p$ measurements for these two compounds provide another test of consistency in the results obtained by high precision diffraction imaging. The similarity in orientation of the quadrupole features in the vicinity of the Nb and Ta nucleus is assembled in Figure 2. The corresponding $\Delta p$ maps shown in Figure 2 resembles strong quadrupolar pseudosymmetry $t_2$ which is as expected for $\pi$-bonding. A pair of $\Delta p$ maxima lie on the [2130] direction across the page and a pair of minima lie on the $c$-axis for the Nb or Ta atom. The strong $\Delta p$ depletion along the $c$ axis, corresponds to removal of density from the cylindrically symmetric quadrupole. In contrast to the sharper density features around the Nb and Ta nuclei, there are slowly varying positive deformation density around the Li nucleus. The similarity of $\Delta p$ topographies of LiO$_6$ octahedra in isomorphous LiNbO$_3$ and LiTaO$_3$ structure is shown in Figures 3 and 4. In these analyses the evaluation of the deformation density is reliable.

Composite of $\Delta p$ sections constructed from $O-O-O$ triangles, bounding the LiO$_6$ octahedron of LiNbO$_3$. Contour intervals $0.5$ eÅ$^{-1}$, positive, negative contours — solid, dashes respectively.

Acknowledgement

This work was supported by the Australian Research Council and IDP. Financial support of the Australian National Beamline Facility (ANBF) is also acknowledged. The ANBF is funded by a consortium comprising the ARC, DITARD, ANSTO, CSIRO, ANU and UNSW. We are also indebted to Professor DC Creagh for his calculations of absorption coefficients and dispersions corrections, to Dr R H Buttrner for his preparation of single-domain LiNbO$_3$ crystals, and to Professor N Ishizawa for his assistance of data collection at the Tsukuba Photon Factory.

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Composite of $\Delta p$ sections constructed from $O-O-O$ triangles, bounding the LiO$_6$ octahedron of LiTaO$_3$. Contour intervals $0.5$ eÅ$^{-1}$, positive, negative contours — solid, dashes respectively.
1996 FEES

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AIP & NZIP NEWS

VIC

September Branch Meeting

The talk given to the AIP Victorian Branch September meeting was on “X-rays from Broken Bones to Antivirals”, by Dr Peter Colman of the CSIRO Division of Biomolecular Engineering.

As many of us are aware, this year marks the 100th anniversary of the discovery of X-rays. Over the past century, X-rays have been used extensively in medicine for imaging our bones and internal organs, but we are generally less aware of their use in developing new vaccines.

One of the major advantages of X-rays is that their wavelength is comparable in size to atomic dimensions. This allows us to use X-rays to probe the structure of matter. Although the interaction of X-rays with matter is generally very weak, a large ordered array of atoms or molecules will scatter X-rays coherently, i.e. diffract them, leading in many cases to strong scattering. The X-ray diffraction patterns produced by this coherent scattering are used to determine the average location of atoms within large molecules, such as proteins. Dr Colman and his colleagues at the CSIRO Division of Biomolecular Engineering have been using X-rays to investigate the structures of proteins found in the influenza virus. This work has enabled them to develop a drug against the virus.

The influenza virus infects us many times throughout our lifetime. With each infection, our immune system generates an antibody of the right shape to bind to the virus. Once bound, the antibody effectively kills the virus. If we already have antibodies that can detect and destroy the virus, then why is it possible for the virus to reinfect us? To understand this, we need to understand the virus. The surface of the influenza virus consists of a lipid bilayer with protrusions of haemagglutinin and neuraminidase proteins. The purpose of the haemagglutinin is to bind the virus to sialic acid which exists in the surfaces of the cells in our bodies. In this way the virus adheres to our cells and can use the reproductive processes within the cell to replicate itself. Thus the haemagglutinin is the protein on the virus that initiates the infection. The purpose of the neuraminidase is also to bind to the sialic acid, but the bond is such that the sialic acid breaks away from the surface of the cell, allows the virus to break free of the cell so that it can infect other cells in our bodies, or be transmitted to other people. If the concentration of the virus becomes too high, we develop the symptoms of infection, such as sore throats, coughs, etc.

While it is not possible to crystallise the virus, it is possible to crystallise the neuraminidase proteins from the surface of the virus and to use X-ray diffraction to determine the structure. A key finding of this structure determination was that the amino acid sequence in the neuraminidase can change causing the molecule to change its shape dramatically from year to year. This means that the antibodies developed last time we were infected do not have the right shape to bind to the virus. Our immune system is unable to recognise the virus the next time it infects us and it must create new antibodies. While the immune system is creating new antibodies, the virus is able to replicate itself to such a degree as to produce the symptoms of infection.

However, the structure determinations also showed that there is a small region on the surface of the virus that has never changed shape over the known evolution of the virus. This conserved site in the neuraminidase is functionally important to the virus. It is the site that binds to the sialic acid in our cells to allow the virus to break free.

The CSIRO group in collaboration with Biota and the Victorian College of Pharmacy were able to develop a drug based on natural molecules in the body that would bind to the neuraminidase and “plug” the conserved site. This means that the neuraminidase is unable to bind to the sialic acid in our cells and the virus is unable to break free and infect other cells. This prevents the virus from replicating itself throughout our bodies and it gives our immune system the time it needs to develop antibodies. The drug does not prevent infection, but it inhibits the progress of infection so that the virus never takes hold and we don’t get the symptoms of infection.

The drug is being manufactured by GLAXO and is currently under trial. Further studies are needed to determine how late after infection the drug can be administered and still be of benefit.

Tim Davis

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PRODUCT NEWS

New Argon Ion and HeNe Laser Catalogue from Uniphase

Uniphase has released a new catalogue of air-cooled argon ion lasers and yellow, orange, green and red helium-neon lasers.

The 2010 air-cooled argon lasers are available in single line, multi-line and multi-mode configuration with powers up to 75mW, 150mW and 300mW respectively. Full details are listed in the catalogue.

Key features of these lasers include high power, high efficiency, and active filter technology resulting in extremely low noise operation. This series incorporates Uniphase's patented, integral-mirror, metal-ceramic laser tube design.

The new catalogue also lists helium-neon lasers with Red (633nm), Green (543nm), Yellow (554nm) and Orange (612nm) outputs.

Uniphase helium-neon lasers includes patented features such as close-cathode design for improved thermal stability resulting in superior beam pointing and power stability, and field concentrator design enabling fast turn-on.

For a copy of the new catalogue, or further information, please contact:

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A basic uniform source system consists of a US Series Uniform Source Integrating Sphere, a source to emit radiation to the interior of the sphere, and a regulated power supply to operate the radiation source.

The sphere collects the radiation from the internal source and uniformly integrates the radiation to create a uniform field of light within the sphere. The exit port serves as a source of radiation that is diffusely emitted from the exit port plane. The uniform source system produces light that is exceptionally uniform over the plane of the large exit port and independent of view angle and which is characterised as radiance (mW/cm²-sr) or illuminance (foot-lamberts). The plane of the port exhibits constant radiance (mW/cm²) or illuminance (foot-candles).

Additional system components include variable attenuators to control the radiation levels and colour balance within the sphere, single or multiple detectors to monitor the illuminance, radiance or chromaticity of the exit port, and a diode array spectrometer to perform a complete spectral analysis. User friendly Windows based software is available for greater control and flexibility in achieving desired light levels.

Further information is available from:
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Ultra Lightweight Laser Eyewear

Laservision has announced a new range of ultra lightweight and super clear laser eyewear. The Nanospec filters consist of thin dielectric layers which are deposited on a highly transparent lightweight substrate. These new filters surpass in clarity current models which use mineral glass products. Extra comfort is available with use of the L-05 spectacle-type frames. The Nanospec range currently includes:

Nd:YAG 1064nm Pulsed/CW
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Other wavelengths will be added soon.

Laservision also offer Polycarbonate goggles for low power applications at a range of different wavelengths, as well as laminated glass models for high power laser safety.

For more information, please contact:
Rob Parvinskis or Narelle Murphy
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116 Burbridge Road, Hilton SA 5033
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Revolutionary GRADIUM™ Lenses Now Available From Newport

Coherent Scientific now offers GRADIUM lenses from LightPath Technologies, which has recently formed an agreement with Newport Corporation to offer all its standard and custom products exclusively through Newport.

Designed and manufactured by LightPath Technologies, GRADIUM, (Axial Gradient Index) lenses bend light rays continuously for diffraction-limited performance without the limitations of achromats, multi-lens systems, or moulded aspheres. Typical applications include laser film recording, optical memory, semiconductor and materials processing. GRADIUM lenses are particularly well suited for semiconductor wafer inspection equipment that requires high magnification and high performance with few optical elements.

Because the lens consists of a single lens element, the new GRADIUM lenses provide a much higher laser damage threshold than cemented doublets. GRADIUM lenses are also less expensive than moulded asphered of similar dimensions.

LightPath’s GRADIUM materials has a refractive index gradient along the lens’ optical axis resulting in the elimination of spherical aberration. Comprising a series of glass layers diffused into a single piece of gradient glass material, these lenses can be produced in much larger sizes than standard GRIN rod lenses or moulded aspheres, and therefore capture more light. For more information about GRADIUM lenses, contact Rob Parvinskis or Narelle Murphy at Coherent Scientific.

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example, aspheres are available only in
diameters up to 12mm, whereas
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The GRADiUM lens won this years
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Photonics Industries International
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  1 hour
ERIC PAUL GEORGE
1914-1995

Eric Paul George was born in England on 15/1/1914. He completed a BSc with first class honours in 1934 and in 1938 obtained his PhD degree from the University of London for his research on cosmic rays. During the war he worked on RADAR systems at Deptford and Twickenham whilst teaching part-time at Birkbeck College under Professor Patrick Blackett.

After the war Paul continued his research on cosmic rays, measuring meson intensities at underground locations (Holborn underground station in London) and led the team at CERN and the Jungfraujoch in Switzerland to measure meson intensities at high altitudes. This involved carrying 7 tonnes of lead bricks to the mountain top! The lack of disparity between the meson intensities at high and low altitude locations also provided a nice illustration of the relativistic time dilation effects which allows the mesons, which have a lifetime of only about 2 μs, to reach the earth’s surface. During this time he also started to develop an interest in the effects of intense radiation on tumours (working with mice at the Beaty Hospital). After a stint as visiting Professor at Rochester University in the USA he was appointed in 1951 as a Senior Lecturer at Imperial College, London. At the invitation of Harry Messel who had then been appointed to head the School of Physics, he joined the University of Sydney in 1953 as a Reader to work on cosmic rays.

In 1956 he obtained a secondment to St. Vincent’s Hospital in Sydney which allowed him to work on the development of Nuclear Medicine. In the following year he joined St. Vincent’s Hospital on a full time basis and started the Department of Nuclear Medicine.

In 1963 he took up a chair in Physics at the University of New South Wales. There he immediately established a Biophysics research group (which was to eventually become the Department of Biophysics). Prior to coming to the University of New South Wales, Paul was involved in a severe laboratory accident at St Vincent’s Hospital. This left him with injuries to the fingers of his right hand. At his interview for the Chair apparently some concern was expressed about his ability to write on a blackboard. Paul convinced the committee that he had made good progress in recovering from the injuries by offering to play the piano for them to demonstrate his dexterity - they declined the offer of a recital but appointed him to the chair!

The University of New South Wales had grown out of the Sydney Technical College and was struggling to establish a research infrastructure and culture. Paul’s arrival did much to support that transition. His enthusiasm for Physics was invigorating and encouraged many. He also initiated extensive course restructuring and promoted teaching innovations. He encouraged the use of demonstrations in lectures and established a demonstration unit in the School. He himself made very extensive use of such demonstrations.

Paul had the habit of wearing a carnation in his coat lapel. I recall having to take one of Paul’s lectures, at short notice, and on entering the Physics Theatre instead of announcing that I was replacing Paul, I ceremoniously pinned a carnation to my lapel. The students caught on immediately and it brought the house down, such had his wearing of the carnations become his hallmark.

He took a very keen interest in all aspects of teaching and, for instance,
when he became Head of School, took it upon himself to personally review in detail every examination paper set by the staff across all years. He had an uncanny ability to spot problems or inconsistencies in questions set. Paul spent a great deal of time with undergraduate students, both in the School and as Warden of Baxter College, to which he was appointed in 1966. Paul was a prime mover in the restructuring of the HSC curricula in the sixties and seventies and also served for some years on the HSC examination board. He was responsive to students needs (and complaints) and would personally get involved in remedial action. A good example of his willingness to help students is illustrated by his bedside tutoring of a student in hospital in Blacktown (some considerable distance from UNSW) over an extended period, to help this student through his exams in all the third year Physics subjects.

He was a young Physicist when quantum mechanics was being developed and his interests in that subject remained with him. In recent years he actively followed and lectured on developments in stochastic electrodynamics. He had a keen interest also in the Philosophical foundations of the subject and debated issues with passion.

The breadth and depth of his knowledge in Physics and his ability to get to the core of a problem was appreciated by all who had the privilege to work with him. He was an expert at iterative numerical computer analysis of problems, but he preferred to search for analytical solutions and his mastery of the mathematics required for this was impressive; right into his eighties he was able to perform, with ease, those nasty and often apparently intractable integrals which we all once learned to cope with in our youth but most of which many of us no longer have at our finger tips.

In 1980 Paul retired but as an Emeritus Professor he continued an active involvement in Biophysics research at UNSW and continued to publish. He was also appointed a Research Associate of the Department of Physics at the University of Newcastle where he also contributed to the laboratory teaching program.

On publications Paul often voiced the strong opinion that the paper must have a section in which we should state our “conclusions”. He insisted that if one has not made a step forward, a definitive observation or cannot conclude something substantial, it probably wasn’t worth publishing or doing it in the first place. That sentiment is most appropriate for Paul’s life and career, he certainly did make very substantial contributions to Science.

Paul will be very sadly missed by many of his colleagues, particularly in the Department of Biophysics. He made so many very significant contributions to the field and was in the middle of a major new project (he had just been appointed to a research position on an ARC funded project). On April 28, just before his travels to Europe, he delivered a seminar in the Department on electrodiffusion in fixed charge membranes. He discovered some important new results which upturned long held dogmas in the field. He had been invited by research groups in Twente (Netherlands) and Berlin to deliver lectures on this work.

The seminar before his departure was excellent. It was, however, to be his swansong. He passed away on June 5th after contracting pneumonia during his travels.

In summary, Paul George was a brilliant scientist who made original contributions in a very broad range of subjects and to development of the School of Physics at the University of New South Wales. He was, without any exaggeration, the most astute physicist I have had the good fortune to know, and to work with. I learned a great deal from him and used him as my role model. I, and here I am sure I speak for all his colleagues, shall miss him a great deal.

Hans Coster
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AIP JOBSEEKERS SERVICE

The AIP has for some time been running a service for jobseekers. The Melbourne Secretariat will send out lists of physics job clippings to anyone who asks to be put on the list. The clippings are supplied by a small band of dedicated and unsung workers around the country. We would be grateful if those who obtained a job through one of these clippings would let me know, as our people in Melbourne would like some feedback on the service. We would also like to encourage the people supplying the clippings to keep up the good work, by being able to provide evidence that their efforts are producing results.

Moira Welch
AIP Secretary
m.welch@uws.edu.au

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Department of Physics

Vacancy UAC.680

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Applications in the form of a detailed CV and including the contact details for two or more referees, including their fax numbers, close with the Registrar, The University of Auckland, Private Bag 92019, Auckland, New Zealand, by 1 February 1996. Please quote Vacancy Number UAC.680 in all correspondence.

W.B NICOLL, REGISTRAR

New Zealand

The University has an equal opportunities policy and welcomes applications from all qualified persons

The University of Auckland

Australian & New Zealand Physicist Volume 32, Number 12, December 1995
Prompt Critical

Making of the Hydrogen Bomb

If ever an author deserved a second Pulitzer Prize it would have to be Richard Rhodes for the long-awaited sequel to his epic volume, The Making of the Atomic Bomb, published in 1986 and immediately recognised as a work of literature. Now, after nine more years of intensive research, he has produced Dark Sun: the Making of the Hydrogen Bomb and it is every bit as gripping and informative as its predecessor.

Isaac Asimov pronounced The Making of the Atomic Bomb to be "The best, the richest and the deepest description of the development of physics in the first half of this century that I have ever read." Rhodes' latest book does take the development of physics a little further, notably the essential recognition of the reflection properties of high-Z elements such as a huge photon flux can provide the necessary impulsive force on the fusion core of a compact hydrogen bomb. However if I wanted to imitate Asimov's accolade I would have to describe the new book as the best, the richest and the deepest description of espionage in the Second World War that I have ever read!

The first half of Dark Sun is almost entirely a chronicle of the espionage which kept the KGB fully informed of the American and British atomic weapon development on an astonishingly regular basis, through a horde of spies including two within the lowest levels of Los Alamos. The Soviets were shipping out plans and documents by the case load from the Lend-Lease base at Gore Field, Montana, right under the noses of the Americans. Most of these details emerged at the end of the Cold War, too late for Rhodes to include in his earlier book. However Rhodes skilfully employs his description of spying activities as a vehicle for conveying new material on atomic bomb development and to set the scene for the transition from fission to fusion devices by both adversaries.

In Dark Sun we have almost the full story of Ulam and Teller's conceptual breakthrough which made a fusion weapon practicable, spiced with a record of the tensions and conflicts which excluded Teller from its implementation. It is contrasted with the roughly parallel work of the Soviet scientists which led to their first hydrogen bomb soon after the American success. The text descriptions are very informative, especially the reasons why the yields of some early American hydrogen bombs exceeded expectations.

A poignant part of Dark Sun is the section devoted to the shameful hearings which revoked Robert Oppenheimer's security clearance and virtually destroyed the man whose indispensable leadership gave America the atomic bomb in the first place. The book closes with an excellent quotation from the conclusions of a high-ranking committee which Oppenheimer chaired in 1952, shortly before he was crucified. The findings are as pertinent today as they were then, and Rhodes appends but three lines of his own: "The world will not soon be free of nuclear weapons, because they serve so many purposes. But as instruments of destruction, they have long been obsolete."

Dark Sun is a monumental tour de force. Read it not for how to make a fusion bomb, but for why not to make one. Published recently by Simon and Schuster in New York, Dark Sun costs $A34.95 which is very reasonable for 731 pages plus 32 black and white plates in hardcovers. Its ISBN is 0 684 80400 X. Buy it while you can, before it comes out in an inferior paperback, which is what happened with Richard Rhodes The Making of the Atomic Bomb.

Colin Keay
Reviews Editor

Reviews

More Than One Mystery

MP Silverman
Springer-Verlag, New York 1995
xx + 212pp., US$38.75 (paperback)
ISBN 0 387 94376 5

This is a fascinating book devoted to unusual or enigmatic aspects of quantum mechanics. Unlike many similar books, it is reflective without being formally philosophical. It is not a book devoted to the "measurement problem" or the "interpretative problem". It is as the subtitle says, "Explorations in Quantum Interference". Further it is not a book for either the lay reader or the highly specialist quantum physicist. It is a book which assumes a knowledge of quantum mechanics at say the level of Schiff's or Messiah's well-known books. It could beneficially be read by a top undergraduate, an honours student, a graduate student, or a professional physicist.

The contents of the book include the following:

An account of "fields without forces", devoted to the Aharonov-Bohm effects. This is extended to a discussion of electrons moving in closed paths, from the benzene molecule to interference in tiny electronic circuits. A rather unique chapter relates to the interferometry of correlated particles, and how that relates to the Einstein-Podolsky-Rosen and Hanbury Brown-Twiss effects. A later chapter discusses interference in time, i.e. quantum beats. The section on atoms in resonant fields will excite the interest of those of us working in the emergent field of atom optics. The final chapter touches on symmetry matters, especially "handedness".

This book is well illustrated, with its "feet on the ground" mathematically and experimentally. I recommend this exciting book to all of you as it is a physicist's book for physicists.

Geoffrey I Opat
School of Physics
The University of Melbourne

Principles of Condensed Matter Physics

PM Chaikin & TC Lubensky
Cambridge University Press
Cambridge 1995
xx + 699pp., A$95.00 (hardcover)
ISBN 0 521 43224 3

On receiving this book and noting the title, a question came to mind as to how the authors had managed to cover (at a non-superficial level) such a vast area...
of physics in just a single book - even though about 700 pages long. Indeed, I was further puzzled to read in its first sentence that "... it is an advanced level text and reference book ...". The question was soon answered, however, on glancing through the contents list. For it was clear that the book brings together most of those topics on condensed matter that are not normally covered in a book on conventional solid state physics, the latter material being mainly excluded from the present work. Although this comment may suggest the title is too sophisticated for the content, it also implies a compliment for it covers these areas of the subject that usually get neglected.

There are 10 chapters, each containing between 3 and 12 separate sections. The chapters include introductory to sometimes advanced discussions of: structure and scattering; thermodynamics; mechnical and statistical mechanics; mean-field theory; field theories; critical phenomena; and the renormalisation group; generalised elasticity; dynamics: correlation and response; hydrodynamics; topological defects; walls, kinks and solitons. A novel inclusion, as chapter 1, is an example on the properties of water treated following the topic-structure used for the remainder of the book.

It is a well written, quality book of substance and depth. The early chapters read easily. However, as the chapters pass a more mathematical theoretical emphasis takes over with subsequent reference and comparison to appropriate experimental results.

At the end of each chapter there are bibliographic and reference sections for those who wish further reading. Several problems are also included to test the reader's comprehension. A glossary of significant terms introduced through the book is presented at the end, which should be helpful to readers.

Finally, who would benefit from having access to the book and how should copies be available? I think certainly people involved in postgraduate courses at our tertiary institutions and researchers generally wanting knowledge on the fundamentals of this area of condensed matter physics.

For those who would like their own copy, I believe it reasonably good value on today's prices and should surely be on the shelves of institutional and research laboratory libraries.

BW Lucas
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The University of Queensland

Modeling in Combustion Science
J Buckmaster & T Takeno (eds)
Springer-Verlag, Berlin Heidelberg, 1989
x + 569pp, DM106 (hardcover)
ISBN 3 540 59224 5

Modeling in Combustion Science covers the proceedings of a workshop on combustion that was held in Kapaa, Hawaii in 1994 and was attended mainly by combustion scientists from the US and Japan together with a small number of scientists from other countries. Each participant presented a major lecture on a specialised topic. Papers based on these lectures constitute the material presented in this volume and cover a wide variety of issues that are important in current combustion research. This text is volume 449 in the Lecture Notes in Physics series and is divided into seven sections.

Section 1 covers turbulence in premixed flames and contains three papers which discuss disagreement between predicted and measured flame propagation velocity.

Section 2 contains 3 papers and discusses turbulence in non-premixed flames. Detailed mathematical analysis which includes the fluid dynamics and the heat & mass transfer processes is carried out but only one step chemical kinetics is included. It is argued that to include detailed chemical kinetics would make the computations so enormous that they could only be done using the most powerful supercomputer.

Section 3 contains 5 papers and covers modeling. The first paper presents a study of methane-air flames and again argues that including detailed chemical kinetics with the fluid mechanics and transport equations makes the computations prohibitive. A reduced chemical kinetics model however enabled the temperature to be modelled using a PC to predict flame temperatures, velocities and spatial distributions of chemical species that match experimental results well. Calculations carried out using an oversimplified chemical kinetic scheme did not match experimental data. The second paper analyses hydrogen flames with detailed chemistry, the third paper discusses combustion at very low gravity and the fourth paper models graphite rod and graphite sphere combustion. The fifth paper discusses diamond growth, has little to do with combustion and seems totally out of place.

Section 4 is entitled Flame-Pressure Interactions and contains three papers. The paper describes adiabatic flames and presents theoretical predictions for flame front velocity that match experiment. In the second paper a study of shock wave passage through flames is given showing that extinction occurs if the pressure drop across the shock front is large enough. The third paper deals with effects of acoustic oscillations on flame propagation in pipes.

Section 5 is entitled Numerical Treatments and covers numerical analysis of various topics presented in seven papers. The first paper discusses application of Mathematica using an Indigo 2 work station to solve problems in combustion and shows that dramatic simplification of the problems is necessary to enable Mathematica to be used. It appears that Mathematica is convenient for visualising solutions to simple models and quickly gaining insight into problems in combustion, but is not much use for analysing a complicated (usual) problem. The material presented in this paper would be a good tutorial problem in undergraduate physics. Paper 2 discusses wavelet theory of flames. Papers 3 to 6 in this section deal with droplet combustion using detailed fluid mechanics and transport equations but only one step chemistry. The seventh paper in this section analyses ignition of a methane-air flame by a hot surface and utilises a detailed chemical kinetic scheme of 61 chemical reactions to predict ignition delay times.

Section 6 is entitled Combustion Waves and contains four articles. The first two papers discuss calculations of flames speeds while the last two papers deal with heterogeneous combustion that is limited by the rate at which oxygen can diffuse through the solid material that is undergoing combustion. Only paper 2 includes a detailed chemical analysis, the others have only one step chemistry.

Section 7 is entitled High Mach Numbers and contains three papers. The first two papers deal with Scramjet combustion and discuss the difficulties of maintaining combustion at supersonic flow speeds. The second paper points out that experiments on supersonic combustion are very expensive and involve great effort - modelling seems to provide more insight. French scientists involved with testing nuclear weapons should take note! The third paper deals with detonation waves. It is somewhat surprising to see only two papers on scramjets.

Overall the work presented shows that many characteristics of combustion systems such as spatial distributions of...
REVIEW

"...complicated spin-wave interactions, which are the foundation of modern theories of ferromagnetism!"

The book comes with a very strong recommendation from Allan Bromley of Yale in the foreword. It contains a wealth of worked examples: for instance, the theory of relativistic gases is illustrated by its application to one of Greiner's favourite topics, the quark-gluon plasma in the Big Bang and in heavy-ion collisions. It deserves serious consideration as a textbook for third-year courses in this area.

CJ Hamer
School of Physics
University of NSW

Operational Quantum Physics
P Busch, M Gaborowski, PJ Lahti
Springer-Verlag, Berlin 1995
vii + 230pp., DM62 (hardcover)
ISBN 3 540 59358 6

This book is the outgrowth of the authors' collaborative research work over the past decade or so. It is a heavily specialised monograph in the philosophical and mathematical tradition associated with the names of Ludvig, Luders, Kraus and Davies. It is more accessible than some others of that tradition. The authors are systematic and careful in their presentation. They do define their terms and set out their theorems neatly. Of course, the proofs cannot always be given in full but the references are plentiful and adequate. The word operational in the title recalls the early, optimistic days of this century when the bold resolve to deal with observable quantities was popular. Quantum theory caught the tail-end of that heady wind and by a simple decree made self-adjoint operators the observables.

By all accounts, the course of discourse and invention that followed was well served. Now, as the great scientific century draws to a close some would like to recall and modify that self-adjoint operators will be better. They may lead to a realistic interpretation in which even the quantum theory will be seen as a theory of individual objects. This is needed for some experiments - which paths do photons really take? This is needed for some experiments which paths do photons really take? Can atoms passing through a cavity be localised? And, as always, how Stern and Gerlach? If such questions are the grist to your mill or if they attract you for their own sake then this book could be just the thing for you.

Kailash Kumar
Theoretical Physics, RSFS
The Australian National University

Renormalisation Group
G Benfatto & G Gallavotti
Princeton University Press
New Jersey, 1995
vii + 143pp., US$14.95
ISBN 0 691 04446 5

This little text does not aim to cover the subject in general but focuses on certain aspects of constructive field theory. Fermi liquids and Bose condensation. It is based on a course of 6 lectures given in Geneva at the "IIrd cycle" level (i.e. higher postgraduate) by Gallavotti and is written in the Rome School style, along the lines of DiCastro and Jona-Lasinio. The authors claim that their lectures are non-technical as they skip boring details which take too long to flesh out. However, I firmly believe that most readers will find the material too daunting to learn from and I think they would do much better to consult the original references. Each chapter is of the order of eight pages and obviously represents about half of one lecture in the series. Earlier on are covered aspects of functional integration and critical points of field theories before consideration of the constructs needed for handling Fermi liquids and the Bose gases. Beta-functions feature prominently and some use is made of the E-expansion. There is also a diagrammatic treatment showing how to circumvent the linear approximation of the renormalisation map, which provides some light relief. The terseness and opacity of the material presented in this text will not appeal to many. I'm afraid this is one complimentary copy that I shall not hang on to.

R Delbourgo
Physics Department
University of Tasmania

Gamma Ray Spectrometry in the Environment
International Commission on Radiation Units and Measurements (ICRU)
Report 53, Bethesda, Maryland USA 1994
x + 84pp., US$50 (quarto paperback)

This report focuses on the use of high purity germanium detectors in ground-based and airborne environmental surveys of radioactive contamination following an accidental release of radioactivity. Methods for analysing spectra, estimating surface contamination levels and determining gamma-ray dose quantities are well covered, and there is also a somewhat shorter discussion of the use of airborne gamma spectrometry for mineral exploration.

For airborne or ground-level environmental surveys of radionuclides

Australian & New Zealand Physicist Volume 32, Number 12, December 1995
contamination, the main source of uncertainty is the assumption made about the depth distribution of the radionuclides. Tables in the report provide conversion factors which allow radionuclide levels per unit area to be calculated from measured fluence rates of primary photons in the air for given values of the attenuation of the primary photon in the soil.

This report is a useful state-of-the-art review of gamma spectrometry as used in environmental surveys. Methods of analysis are clearly presented and limitations of the methods authoritatively discussed.

JR Harris
Environmental Science
ANSTO

Photonic Crystals
John D Joannopoulos, Robert D Meade & Joshua N Winn
ix + 133pp., US$35.00 (hardcover)
ISBN 0 691 03744 2

Exploitation of the electronic properties of materials, especially semiconductors, has induced scientists and engineers to develop techniques to engineer new materials with particular properties. Epitaxially grown bulk and thin films of semiconductors have their electronic bandgaps tailored to the intended use. The authors of this book pose the question: Can we engineer materials whose optical properties can be designed in an analogous way? The answer presented here is "Yes", and this volume discusses, mostly theoretically, how one can design and calculate the properties of these artificial Photonic Crystals.

Photonic crystals, which can exist in 1, 2 or 3-dimensional form, are materials whose dielectric constant varies periodically in space. Most readers would already be familiar with one form of 1-dimensional photonic crystal, the multi-layer dielectric stack, whose wavelength selective optical properties (reflectance, transmittance) make it an important component in many optical systems.

The book casts Maxwell's equations for dielectric media as a single Hamiltonian differential equation, a form in which the dispersion relations for modes of the photonic crystals can be relatively easily evaluated. The orthogonality of modes, and the electromagnetic variational principle are presented, together with a complete chapter devoted to questions of symmetries of the crystals, and the optical consequences of those symmetries. Early in the text, the concept of a photonic bandgap is introduced, in analogy with the electronic bandgap studied in solid state physics. Three informative appendices detail the analogy between quantum mechanics of crystals and the electromagnetics of photonic crystals, a review of the concept of the Brillouin zone in momentum space (equally applicable to photonic as to conventional crystals), and an atlas of photonic bandgaps of various photonic crystals.

Chapters are devoted to detailed discussions of 1, 2 and 3-dimensional photonic crystals. These chapters are well written and informative and amply illustrated, and a great strength of the text is the frequent reference to the underlying physics of phenomena presented. I was personally disappointed that the authors made no reference whatsoever to the recently developed optical fibre Bragg gratings, which are exciting new examples of 1-dimensional photonic crystals.

Indeed, the book devotes only one short chapter to practical examples of photonic crystals, including the eponymously named Yablonovitch. Such important concepts as point defects in photonic crystals, which are amply discussed theoretically, could have been well illustrated by reference to phase-shifted distributed feedback resonators commonly used in semiconductor lasers, or to the recent work on phase-shifted fibre gratings. Indeed, practical applications of photonic crystals are left mostly to the imagination of the reader.

The book should appeal to any reader who is keen to gain an insight into every new field of optics, which is, by the authors' admission, still in its early infancy.

Peter A Krug
Optical Fibre Technology Centre
University of Sydney

New Books

The Light Element Abundances
P Crane (ed)
Springer-Verlag, Berlin 1995
xvi + 432pp., DM 49.80 (hardcover)
ISBN 3 540 58978 3

Quantum Mechanics Using MAPLE
M Horbatsch
Springer-Verlag, Berlin 1995
x + 331pp. plus disk
DM 78 (hardcover)
ISBN 3 540 58873 2

Scanning Tunneling Microscopy II
R Weisendanger and H-J Guntherodt
Springer-Verlag, Berlin 1995
xiv + 439pp., DM 89 (softcover)
ISBN 3 540 58589 3

Sun, Earth and Sky
KR Lang
Springer-Verlag, Berlin 1995
xvi + 282pp., DM 58 (hardcover)
ISBN 3 540 58778 0

Beyond Quasicrystals
F Axel & D Gratias (eds)
Springer-Verlag, Berlin 1995
xvi + 619pp., DM 158 (paperback)
ISBN 3 540 59251 2

Random Walks and Random Environments
BD Hughes
Oxford University Press, Oxford 1995
xvi + 631pp., AS 120 (hardcover)
ISBN 0 19 853788 3

Trends in Optical Fibre Metrology and Standards
ODD Soares (ed)
xii + 850pp., US$317.00 (hardcover)
ISBN 0 7923 3402 7

Complex General Relativity
G Esposito
xii + 201pp., US$69.00 (hardcover)
ISBN 0 7923 3340 3

The Materials Science of Microelectronics
KJ Bachmann
VCH Publishers, New York 1995
xvii + 541pp., DM 128 (hardcover)
ISBN 0 89753 280 7

Hartung's Astronomical Objects
For Southern Telescopes
Second Edition
D Malin and D Frew
Melbourne University Press, Melbourne VIC 1995
xix + 428pp., AS 79.95 (hardcover)
ISBN 0 522 84553 3

Laser Experiments for Beginners
RN Zare et al
University Science Books
Sausalito CA 1995
xviii + 232pp., US$26.00 (paperback)
ISBN 0 935702 36 9

Gravitation and Inertia
I Ciufolini and JA Wheeler
Princeton University Press
Princeton NJ 1995
xiv + 498pp., US$49.50 (hardcover)
ISBN 0 691 03323 4

Introduction to Plasma Physics
RJ Goldston and PH Rutherford
IOP Publishers, Bristol 1995
xvii + 491pp., plus 2 Disks
UK £29.50 (paperback)
ISBN 0 7503 0183 X
CONFERENCES & MEETINGS

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January 8 - 25  
Ninth Physics Summer School: Computational Physics.  
National Centre for Theoretical Physics, Department of Theoretical Physics,  
RSPhysSE, ANU Canberra.  
Contact Ms Martina Landsmann. Tel (06) 279 8123, fax (06) 249 4676,  
email Martina.Landsmann@anu.edu.au

January 8 - 12  
IAU Colloquium 160 Pulsars: Problems & Progress, Sydney Australia.  
Sponsored by: IAU, ATNF, RCFTA, URSI  
Contact Prof DB Melrose, RCFTA, School of Physics,  
University of Sydney NSW 2006. Tel (02) 351 2542, fax (02) 660 2903,  
email iau@physics.usyd.edu.au,  

January 29 - 31  
GEM-9, Ninth Gaseous Electronics Meeting, Flinders University.  
Contact Dr Bruce Wedding, School of Applied Physics,  
University of South Australia, Levels Campus SA 5095.  
Tel (61) (8) 302 3244, fax (61) (8) 302 3389,  
email phabw@levels.unisa.edu.au

February 12 - 17  
1st Australasian Conference on General Relativity and Gravitation, University of  
Adelaide. The conference will cover all aspects of theoretical and experimental  
research in gravitation, including workshop sessions on gravitational wave  
interferometry, mathematical relativity and quantum gravity. See the conference web  
Contact Sharon Johnson, Institute for Theoretical Physics,  
University of Adelaide SA 5005. Tel (08) 303 3333, fax (08) 303 3551,  
email sjohnson@physics.adelaide.edu.au

July 1 - 5  
Twelfth AIP Congress, University of Tasmania, Hobart.  
High profile speakers will present papers on the challenges of physics  
in their areas of expertise. See the conference web page at  
Contact (accommodation and registration) ApplePhys'96, Mures Convention  
Management, Victoria Dock, Hobart TAS Australia 7000.  
Tel (002) 34 1424, email mures@hba.trumpet.com.au  
Contact (scientific program) Prof R Delbourgo, Physics department,  
University of Tasmania, GPO Box 252C, Hobart Australia 7001.  
Tel (002) 20 2403, email Bob.Delbourgo@phys.utas.edu.au

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January 20 - 24  
First Asia Pacific EPR/ESR Symposium.  
Department of Physics & Materials Science, City University of Hong Kong  
Co-sponsored by The Croucher Foundation and Lee Hysan Foundation  
Contact Professor Czeslaw Rudowicz, Chairman, LOC & IOC,  
Department of Physics and Materials Science, City University of Hong Kong,  
83 Tat Chee Avenue, Kowloon, Hong Kong. Tel (852) 2788-7787,  
fax (852) 2788-7830, email APSEPR@cityu.edu.hk
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The Australian Journal of Physics has established a home page on the World Wide Web (http://www.cis.csiro.au/cis/journals/aip/index.html). From this page you can access items such as the Notice to Authors, the Editorial Board, subscription prices, etc. You can also link into the contents pages of 1994 and 1995 issues, or look at a listing of papers in press.

The next step will be to make the full electronic files of papers available to subscribers of the journal. The development of such a service is currently under way at CSIRO Information Services in East Melbourne. Plans are to trial a limited service later this year.

If you would like to know more, please contact Peter Robertson at rob366@cis.csiro.au.

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