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The cover this month commemorates the centenary of the discovery of X-rays by Wilhelm Roentgen on the 18th of November 1895 at the University of Wurzburg. Subsequent developments of this discovery, particularly by the Bragg’s father and son, and more recently by Australian physicists, is discussed in the article on page 215 of this issue by John Patterson who also supplied this month’s cover picture. The equation is the famous Bragg equation, basic to all X-ray crystallography. The hand X-ray is of William Bragg’s hand, taken in Adelaide in 1896. The injury to the tip of his little finger was sustained while working as a farmer’s son in his youth. Printed full size copies of this post are available for $10 each from John Patterson and can be ordered via email jpattern@physics.adelaide.edu.au.

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PRESIDENT’S COLUMN

A Meeting of Heads

The Executive played a large part in the organisation of a meeting of Heads of Physics Departments (and Schools and Disciplines and Groups) held in Canberra on Thursday and Friday, October 5 and 6, respectively. The Research School of Physical Sciences at ANU kindly provided the meeting rooms, etc. and for this we express our thanks to Eric Wiegold and Brian Robson.

The meeting was attended by a Head (or a representative of the Head) of almost every Physics Department in Australia. The group has not met since the Melbourne Congress and there were a large number of new faces. This highlights the need for a regular meeting of this kind. The sharing of experiences by newer members to this group will always be of benefit in establishing the member in the position. It has been decided that the Institute will continue to organise these meetings. There will always be a meeting at the Congress and another will be organised at a time between Congresses.

This meeting was wide-ranging in its subject matter. This was deliberate, with the intent of identifying issues which will be considered in detail at the meeting associated with the Congress in Hobart. Much of the discussion centred around the promotion of Physics as a desirable discipline from which one might launch a career. To this end, Mal Heron from JCU provided very interesting data which used the Graduate Careers survey data to demonstrate that, in the area of Physics there was a substantially lower percentage of graduates seeking employment, about six months after the completion of their first degree. This data will be included in a paper Professor Heron has been asked to publish in *The Physicist* in the near future.

The meeting resolved to seek further details in a number of areas from Departments and produce a series of short articles for *The Physicist*, some of which will be intended to promote discussion rather than provide solutions at this time. This includes some details on funding to Departments, allocation of Research Quantum, models used for funding and other data useful to managing a Department in these times.

There is to be a sharing of experience on the promotion of Physics to employers. The WA Branch, with assistance from the AIP, has produced a good video, using role models, to help in student recruitment. This video will be available to Departments and Branches soon, and there will be the possibility of distributing the videos to schools. Members will, I hope, be aware of the posters we have recently produced for the same purpose. These have been widely distributed to schools and we have a number of requests for more of them.

The extent to which we might use new technologies, such as multimedia presentations, interactive or otherwise, to support the teaching of Physics was explored in some detail in one session and arose in a number of other instances. It emerged that there was a lot of experience with these technologies, some good, some not so good, but all indicative of a slow return on the investment of resources to develop such tools. A survey will be undertaken to assess the material currently available, plus the experiences of its development and use and the results published. In particular, a CAUT grant to The University of Canberra (John Rayner) has led to an interactive CD ROM course on Atomic Physics relating to first year courses. This will also be available to Departments in the near future.

I believe the meeting was a great success. There was spirited discussion of topics and almost all the attendees contributed. There were a number of on-going topics to be developed, including more information to do with the AIP’s accreditation process, and these will generate papers (mainly for *The Physicist*) to inform and promote discussion by physicists in general.

We look forward to a constructive meeting in Hobart in July 1996.

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EDITORIAL

AGE AND RENEWAL

For those of our readers who turn first to the obituaries, rather than the job offers, it may come as welcome news that people reach their sexual prime in their 60s. This information comes from Dr David Schnarch who is, of course, an American, conducting seminars in Australia (Sydney Morning Herald 3 October 95). I can’t help feeling that Dr Schnarch is nearer in age to 60 than to 17, although as a psychologist this naturally will in no way influence the objectivity of his findings. Most of our younger readers will not easily accept his assertion. But then an important part of being young is the belief that you are discovering new things for the very first time and that you will do much better than the old fogies who at present hold the reins of power and influence.

Fortunately for humanity this belief occasionally turns out to be true, particularly when the oldies assure us that something can’t be done, or that a particular field has reached the end of the line. They unconsciously associate a decline in the scientific area that has occupied a significant part of their lives with their own impending demise. Though usually not as strongly as Natalie Angier who holds that; “Death for me is a wasteful obscenity. You spend your life mastering tasks, cultivating knowledge and opinions, gradually getting the hang of living in your skin and skull, when it all must be disposed of to make way for the latest models coming up from behind. Nature is a spoilt brat who needs a perpetual supply of new toys.”

A century ago Lord Kelvin worked out that the Earth was molten only 20 million years ago. Based on heat flow calculations from temperature measurements made in mines, he was correct. The error was the neglect of heat from radioactivity which nobody yet knew about. He also maintained that all that remained for physics was to measure things to an extra decimal place. Far from just improving measurement techniques, this century has seen physics blossom as never before.

Yet the error of believing it is now nearly wrapped up is being repeated. Do you really believe, with Stephen Hawking and many of our most respected theoreticians, that the General Theory of Everything is just around the corner? After which, presumably, all we will have to do is go around adding the extra decimal places. Do you believe that we now understand all the forces that exist in the universe? Do you believe that the Big Bang is the only possible cosmological theory? I don’t think we need worry that there will be nothing left for the next generation of physicists to do nor that there are still surprises in store for us.

Near the beginning of this century, the electron, radioactivity and quanta turned up, to revitalise physics and change Kelvin’s opinion. As one of this years numerous memorials to the centenary of Roentgen’s discovery of X-rays, in November 1895, we publish in this issue John Patterson’s article on almost 100 years of X-ray research in Australia. It is an area to which many Australian scientists have contributed significantly and many continue to do so.

Even after all these years, X-rays and Bragg scattering are showing no signs of becoming gericritic as research fields. Eighty three years after the Braggs used X-rays to solve the structures of crystal lattices, where the lattice spacing is about an angstrom, essentially the same method has recently been used (G Birkl et al. Phys Rev Letters 9 October 1995) to find out how swarms of atoms in atom traps arrange themselves. The cesium atoms in the trap were about a microm apart, so a laser of about this wavelength was used rather than angstrom wavelength X-rays. The Bragg scattering clearly distinguished between a random swarm of such atoms and an ordered array, even when most lattice sites are unoccupied, thus opening a new and fruitful application for an ancient method.

Jak Kelly
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VIC

July AIP Victorian Branch Meeting

The TH Laby Medal, named in honour of Thomas Laby, professor of physics at the University of Melbourne from 1915 to 1944, is awarded annually to the outstanding Honours Physics student(s) in Victoria. The 1994 Laby Medal was presented to Mr. Tan Tat Hin (Monash University) and to Mr Martin Hecht (University of Melbourne) at the July 1995 Victorian Branch Meeting.

The presentation was made by the Hon. Peter Hall MLC, representing the Victorian Minister for Tertiary Education and Training, Haddon Storey. Jean and Betty Laby, daughters of the late Professor Laby, attended the presentation, which appropriately was made in the Laby Theatre of the University of Melbourne School of Physics.

The subject of Tan Tat Hin’s Honours project was the Gravitational Aharonov-Bohm Effect, and Cosmic Strings, while Martin Hecht’s project dealt with the Dipole Moments of Vector Mesons.

Following the presentation, optics was the theme for the rest of the evening as Dr. Bill Jagger from Monash University spoke on “The Marvellous Optics of the Wily Trout.”

This was a fascinating description of how a trout sees. Dr Jagger showed that many tools of optics, such as the star test, the Schlieren test, catastrophe theory, and speckle theory are useful in determining how well the trout’s eye works. With its cornea (which doesn’t do much optically, having a refractive index close to that of water), its almost spherical lens with a highly graded refractive index to overcome spherical aberration, and its concentric retina, the trout’s eye bears many similarities to human and other vertebrate eyes, suggesting the fish’s eye may be an evolutionary precursor to our own. But there are differences as well - the trout, for example, unable to change the shape of its lens, achieves accommodation by moving its lens backwards and forwards.

The trout has visual acuity of only about five cycles per degree of angle of view, apparently a consequence of the severe chromatic aberration its eye produces. It seems that the fine detail on expensive fishing lures is appreciated more by the fisherman than the fish.

Russell McLean
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The photograph shows (left to right) Dr Richard O’Sullivan, Vice-Chairman of the Victorian Branch of the AIP, Laby Medal WInner Mr Martin Hecht (University of Melbourne) and Mr Tan Tat Hin (Monash University), and the Hon Peter Hall, MLC, who presented the medals.

JOIN NOW

If this isn’t your copy of the ANZ physicist then you are not a member. You should join, not only to get this journal every month and find out what is happening in Australasian physics and physics education, but to support the many activities that the AIP and NZIP carry out on your behalf. Most of the work is done by people who give considerable time and effort to advance physics. But we still need funds and every new membership helps. If you are already a member, why not make an effort to recruit others?

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Membership regulations and application forms are available from: Dr GJ Fraser, Secretary NZIP, Department of Physics & Astronomy, University of Canterbury, Christchurch, New Zealand. Tel +64-3-364-2581 / Fax +64-3-364-2469.
BERNIE MILLS: INVENTOR OF THE MILLS CROSS TELESCOPE

RAGBIR BHATHAL

Bernard (Bernie) Mills suffered a heart attack not long before I interviewed him. He is a soft spoken man. At 75 he still displays a lively intellect. Born in Manly, Sydney in 1920 he has lived in the Sydney area all his life. He came from a professional middle class family. His father was an architect and his mother a dancing teacher before she got married. He was the only child. He graduated from the University of Sydney with science and engineering degrees. He had no plans of becoming an astronomer. He became one by chance and a good one too. He invented the highly innovative and famous Mills Cross telescope. "It enabled", he says, "maps of the sky to be produced with quite high resolution and enabled accurate positions to be determined, of sources, of a very large number of radio sources". He was elected a Fellow of the Australian Academy of Science and a Fellow of the Royal Society of London for his contributions to astronomy.

He spoke with me at the Bankstown Campus of the University of Western Sydney, Macarthur about his early life, influences, astronomical discoveries and opinions on some issues facing contemporary Australia. This is an extract of that interview and deals mainly with his astronomical work.

RB: After finishing university you joined the Radiophysics Division of the Commonwealth Scientific and Industrial Research Organisation (CSIRO). What motivated you to join the CSIRO?

BM: Well, there was really no choice. A war was on and in 1942 that I did my final exams and the whole of the electrical engineering honours group were transported immediately to work in radiophysics, which was in urgent need of young trained people to help develop radar. I started off in the receiver section and rapidly worked my way through that and became interested in display and presentation of information, and finished up being an expert in receiver and display development.

I also did a bit of research work at the time with Ruby Payne-Scott on the visibility of weak PPI signals - that's planned position indicator signals - which stood me in very good stead later on when I was looking for weak astronomical signals.

After the war the radiophysics division had on its hands a group of brilliant young men. What was the culture of the place at that time and who was the leader?

Well, it was an interesting situation at that time because there were two outstanding people; Joe Pawsey and Taffy Bowen. They were miles apart in their outlook on life. Pawsey was a first-rate scientist but poor at administration, and in fact had no interest in administration or organisation. Bowen, on the other hand, was a brilliant organiser and administrator but, in my view, a poor scientist. But the two together made a very powerful combination.

However, there was friction there, as you might imagine, given those differences. This grew with the years and towards the end, before I left, there were two distinct camps. There was the Pawsey camp and the Bowen camp and I belonged clearly in the Pawsey camp. So it was an extremely interesting time and Pawsey was a very stimulating group leader.

This is an extract from Dr Bhathal's forthcoming book Astronomers in Australia: A Dialogue With Australia's Astronomical Elite. Dr Ragbir Bhathal is at the University of Western Sydney, Macarthur. r.bhathal@uws.edu.au
Bernie Mills: Inventor of the Mills Cross Telescope

Did Pawsey have any influence on your scientific work?

Oh, very much so. Well, the first thing I remember on joining radio physics was when he gave me a course of lectures on a very mathematical approach and he produced a physical approach. But after the war, well, I was working with him a lot during the war when I became interested in radio astronomy, he was my mentor really. He was really outstanding; there’s no question about that. He was one of the best of the people there by a long shot.

What was Pawsey’s style of management?

Well, he used to leave you very much to yourself. But having talked over a problem you’d go away and do it. If you had any problems arising as a result of your problem you could always go back to Pawsey and he would always come up with some good suggestions.

Can you tell us about your research work while you were employed in the radio physics division of the CSIRO?

Well, at the end of the war, I had a brief stint on making a very high energy accelerator – this was an idea of Bowen’s – but it was decided that manufacture of such things in Australia was really not on; we didn’t have the technology in the background. So I then spent some time working on the first computer with Trevor Pearcey. This was a digital computer in which the ideas were imported from England from FC Williams. Pawsey gave me the choice of either continuing with the computer or doing astronomy. And at that time Bolton had made his first discovery of point radio sources, a class of point sources, and this really intrigued me. So, as far as I was concerned, there was no choice, I went into that, although I was by no means an astronomer.

How did the idea of inventing the Mills Cross come about and what is the principle behind its operation?

Well, let me see, it developed out of quite a number of observational programs. I started off trying to measure very precisely the position of Cygnus A, the radio source. Then I went on to do a survey of radio sources and measure more positions. This involved bigger antennas out at Badgery’s Creek. There I had an interferometer with two separate spacings; a small spacing and large spacing. The ideas was a small spacing would determine the approximate position of a source. And then with the large spacing, you’d tie it down exactly.

But I found to my surprise that the radio sources looked different on the small and large spacings. They were a different class of sources being picked up in many cases. I did a survey and we found that there was a lot of large sources. These sources which were being picked up on the close spacing had a large diameter. They didn’t show up on the very wide spaced interferometer. We found a lot of these large sources and we found there were two classes of source: one in the galaxy, obviously along the galactic plane and the other more or less uniformly distributed. Well, there were two classes of source and...
one was obviously galactic and the other one, we couldn’t really be sure whether it was galactic or extragalactic, but the identifications which were then coming along suggested they were probably extragalactic.

But to examine all these in detail it was clear that you couldn’t use interferometers because they didn’t give you the whole picture of what was in the sky; only one Fourier component of the picture. So I set about trying to think of a way of making a cheap pencil beam instrument. Now, to make a simple reflector like the Jodrell Bank one, with sufficient resolution and sensitivity to see a large number of these radio sources, would have been terribly expensive. I mean, Jodrell Bank was the sort of which . . . I’m not sure whether it was actually . . . I think it was a very expensive proposition. So I had to think of a cheap way of making a pencil beam instrument, and so this idea occurred to me.

What you really want is resolution, not sensitivity, for low frequency radio astronomy. The sources are strong enough, but they’re so close together you can’t resolve them separately. And you also want to examine the structure of large sources, so you need a pencil beam, but you don’t need the complete area of a filled antenna. So the idea occurred to me of having two long arrays, thin arrays, at right angles crossing in the centre, and multiplying together the outputs from each of these arrays. This is easy to show, produces a pencil beam response in which the resolution, the angular size of the pencil beam, is dependent on the length of the arms and the sensitivity only on the total area of the arms. It was possible to tailor such an instrument to see just what you wanted it to see, so I was able to do that and go ahead with the Cross.

Why is it considered such an important instrument in astronomy?

Well, it was the first time large numbers of radio sources could be seen certainly, and larger ones could be mapped. It did what was expected of it; it enabled maps of the sky to be produced with quite high resolution and enabled accurate positions to be determined of a very large number of radio sources. In fact our catalogue was over 2000 sources in the end, detected with the instrument. We found an awful lot of astrophysical things of interest. For instance, we found the centre of the galaxy had an absorption dip in it caused by ionised hydrogen and also many other regions of ionised hydrogen showing absorption; we showed this for the first time.
We were able to scan the Magellanic Clouds and map them and study individual sources in the Magellanic Clouds. We were able to look at a lot of normal spiral galaxies and learn quite a lot about their physics. So all round at that time, it resulted in a big step forward in quite a number of things which were of great interest, and questions of great interest in astronomy at that time. For a time anyway it was preeminent among radio telescopes in this respect.

Actually, there was some opposition to your plan of building the Cross by the people at the CSIRO. Why did this arise?

Oh well, that I think was part of the Pawsey-Bowen camp division. When I put it up Bolton (John) was very antagonistic and through it wouldn't work at all. In fact, he convinced Bowen of this, who I remember told me quote clearly and unequivocally that it couldn't possibly work. However, Pawsey was behind me and so we had to build a small experimental model first, just to show that it would work, which it did. And, in fact, we discovered the radiation from the Magellanic Cloud using that small instrument. So I think that was one of the first occasions where it became obvious there was quite a division in the laboratory.

You mentioned the use of Fourier methods earlier on. It is intriguing to find that the use of Fourier synthesis in astronomy was first suggested by Australian astronomers. Was this followed up in Australia?

Yes, that's right. Pawsey and Payne-Scott in one of their first papers suggested Fourier synthesis was a way of getting distributions over radio sources, and we always had this in mind. In fact, in about 1952 I think, Christiansen in his surveys of the Sun using the grating array, used Fourier synthesis techniques to build up a map of the Sun. So I think it was the first time rotational syntheses was used too.

But we were missing the essential ingredient to make Fourier synthesis a real going concern; that is, we didn't have a good reliable fast computer available. I think all the ideas about Fourier synthesis were presented at one time or another by one person or another, but as I said it never really occurred to us to try it because we knew what a difficult business the Fourier synthesis was when done with one of these hand-cranking computers.

Your work with the Mills Cross led to an international controversy with the Cambridge University group of astronomers. Can you tell us what this controversy was about and how it was finally resolved?

Well, we had just got the Cross working and started looking at the sky when I received a letter from Fred Hoyle to the effect that Ryle (Martin) had just completed a new survey, and there were 2000 sources in it, or something of that order. He found that there was an enormous excess of very faint sources. There were far too many more than expected in a uniform distribution and he interpreted this as meaning that he was seeing extragalactic, very distant objects, and we were in an evolving universe: it obviously must be evolving if they were more distant ones than there were close one. And this didn't fit with Fred Hoyle's idea of a steady state universe, so he wrote asking was this true.

So I had quite a lot of information although we only had several hundred radio sources. So I did a quick check and said no, it wasn't true. We found that there was no statistically significant excess and the sort of thing which Ryle was talking about was just impossible. This was about the situation which went on for a while. When I corresponded with Ryle about this and pointed out that we didn't seem able to get his results, he helped by sending out a preliminary list, a portion of his catalogue which was in press at the time. It naturally permitted checking in detail. And we did this and this is quite a famous check. We found that about 5 per cent of his sources were correct and the rest were fictitious.

The reason was that he didn't have enough resolution to separate out all the sources. What he was doing was, instead of seeing an individual source, one after the other, he was seeing just a random distribution of bright objects all over the sky, all coming in his beam at once, and just producing random deflection. So that I sent him my data with sample records and things, but this didn't stop him; he went on with his ideas. Eventually, as a result, we entered into this quite public controversy. It basically arose because he didn't have enough resolution with his 2C survey, as it was called, to separate out and see separately radio sources; he was just getting a blended mixture.

We completed our analysis of this region of sky and published the results and showed how the difference arose. We sent Ryle a copy and he didn't reply but Peter Schuer wrote back and I had a bit of correspondence with him. In the end he agreed that their catalogue was no good, but they had what's called a P of D analysis in which they just analysed the percentage of deflections above a given range, which he said also showed the same effect, confirming their conclusions.

But I knew that again this would only be true in a uniform distribution of point sources. If you had a structured distribution, clustering, or if you had large sources then you get exactly the result they got. So anyhow, that was the situation. So they went ahead and, after backing down appreciably, doubled the frequency their interferometer was using, which gave a quarter of the area for each beam, and they restricted their next catalogue to just about an order of 300 instead of 2000. So that's four times the area and a sixth of the number of sources. So they were an order of magnitude better, and this 3C survey was good and it agreed pretty well with mine. We both got the same sort of source counts in which there seemed to be a slight excess of faint sources, but I wasn't prepared to give any cosmological significance to it because I saw it could arise in several ways. So that was about it.

So what happened to Hoyle's steady state theory?

Oh well, other things have shot that down by now, yes. Not this. The microwave background is the principle thing that shot that down.

You left the CSIRO in 1960 to join the University of Sydney. What motivated you to leave the CSIRO?

Well, remember there were two camps in the CSIRO. Now, Bowen was pursuing and had got the money for a single dish, the Parkes dish, and this was coming along and it was obviously a very useful instrument. But given the specification at that time it was clear that I could build a Cross very much cheaper which would have outperformed it for survey work. That's to say for looking at radio sources, it would have had better resolution and better sensitivity.

I proposed the construction of such an instrument but it became clear that there was not enough funds. I mean, the Parkes dish was absorbing an enormous amount of money, and
to have made it practical at all, to have made my Cross practical, it would have been necessary to close down the solar program, which really wasn’t on. It was a good going program and Paul Wild was looking towards making a new instrument too.

So what I did was started looking round elsewhere. Could I find some support somewhere else to build such a Cross? Then Messel (Harry) came to the party and he offered me a position in physics at the University of Sydney as a Reader and he could put up at least $100,000, possibly $200,000, towards constructing such an instrument. This was barely enough. He also said that it was very likely that with his contacts we could get overseas funding as well to go towards it. So after much heart searching I decided to leave and to join the physics group, with the idea of starting a radio astronomy group there – there was no one interested in radio astronomy as such - and building a big Cross.

Was there some ill-feeling between the CSIRO and the University of Sydney arising from your departure and your decision to build a more powerful instrument than the Parkes Radio Telescope?

There certainly was on Bowen’s part. Again, the Bowen camp was pretty well against it, but the Pawsey camp was in favour. Pawsey was always a great one for building high performance instruments on the cheap, and he supported me there. But apart from that there was very bad feeling on Bowen’s part. He would hardly speak to me after that. When we eventually were looking for funds from the US National Science Foundation I know that a letter was sent from Radiophysics saying that it would be money down the drain and not to worry about it. Well, fortunately that question was resolved and we got our money; enough to build an instrument of just the sort I really wanted to build, and not the sort that I might have been forced to build if I’d had to stick with Harry Messel’s money.

Was the building of the Parkes Radio Telescope also one of the reasons why Pawsey left?

I think it was partly that and it was the way things were going. Bowen was increasingly taking charge and he was importing his offside, John Bolton, from Caltech to become manager of the Parkes dish. And really, Pawsey could see little scope for himself in Radiophysics, since my project was going elsewhere and Christiansen (Chris) had left and was also going elsewhere – to Sydney University. He (ie Pawsey) got this offer from the US National Radio Observatory and he was on the point of taking it up when he was struck by this sickness, a brain tumour.

In 1962 you established the Molonglo Radio Observatory near Canberra. Could you tell us the scientific aims of this observatory and the kind of research that was carried out at this time?

I think I said before that I had believed that we needed a Cross telescope as a complement for the Parkes reflector, since they do different sorts of things. The Cross telescope is fine as a survey instrument and can get very sensitive. So one of the things I had in mind at that time was the construction of a very sensitive survey instrument which would locate radio sources, very faint radio sources, and measure their positions accurately. This was necessary for doing optical identifications, to decide what the sources were and their general distribution in the sky.

This was the sort of bread and butter aim of the observatory and, given the money made available by the National Science Foundation, this was easily achieved. But at the same time I was able to make provision for rapid changing of settings so that we could examine individual objects as well as making surveys. But, again, it was a matter of looking at all sorts of astronomical objects to see what their radio emission was like and trying to explain why.

The radio-emission of objects, such as galaxies or emission nebulae or something like this, is very important in giving us

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clues as to the physical conditions inside these objects. So this
was important and we were planning detailed surveys of the
galaxy itself, the southern part of it, and the Magellanic Clouds
too. All these are sort of vital problems in astronomy. The
radio emission always gives us information about the physics
involved, what the physical conditions in these objects, and
some clues sometimes about evolution of things like supernova
remnants.

So these were the basic aims . . . At the same time we were
training PhD students who were all working on these
problems.

The telescope was used to discover some of the first pulsars
in the Southern Hemisphere. Can you tell us what are
pulsars and why are they important in the study of
astronomy?

The pulsar discovery work was not planned. They had been
first discovered in Cambridge in '68 - end of '67 - so all
telescopes throughout the world started looking for them.
We were the first to discover any in the Southern Hemisphere, and
it turned out that the Molongo Cross was very well suited for
finding new pulsars - discovering them.

Pulsars are condensed stars; they're called neutron stars.
Basically, they're an enormous atomic nucleus, about the mass
of the Sun and the size of the order of 20 kilometres or so.
They're about the most concentrated matter we know of. In
fact, we contributed towards this understanding, I think rather
substantially.

They spin. They occur when an old, an evolving star explodes
to form a supernova and they leave behind this remnant of
neutron star which may become a pulsar, but need not
necessarily do so. A general idea is that they are spinning
neutron stars which are squirting out radio emission in a beam
which just passes us by at regular intervals, producing radio
pulses in our receivers. This is how they were first discovered;
as a series of regular radio pulses. Their importance is hard to
... well, first of all, let me say how we contributed to this
because I've said that they were originating from supernova
remnants. Well, this wasn't known at first. It was not known
what on earth they were.

However, we found quite early on that one of the pulsars - in
fact, the fastest one then known; one with a shortest repetition
period of about 10 a second occurred at the position of a known
supernova remnant in the south. So I wrote this up for Nature
and then shortly afterwards a similar pulsar was discovered in the
Crab Nebula, another supernova remnant, and that fixed it.
They were obviously associated with supernova remnant. A
neutron star; that's the thing that's left. They had to be very
very small in order to produce short pulses of radiation.

They tell us a lot about the evolution of stars, since they
represent the end result of evolution. But all sorts of new uses
or contributions from them turn up, such as the proof that the
Einstein general theory of relativity was correct in dealing with
very high gravitational fields in which these pulsars existed. So
altogether they were like any new discovery in astronomy; they
lead to all sorts of ramifications in the end.

Who was at the telescope when this discovery was made?

Michael Large and a student, Alan Vaughan (now at
Macquarie). They were down there observing, looking for new
pulsars, and they discovered this very fast pulsar. Michael rang
me and told me what they'd found and where it was. So I
immediately thought 'ah, that sounds familiar. The position
sounds familiar. So I looked up my radio catalogues and sure
enough it was right at the centre of a supernova remnant. I
immediately got down to work and wrote up the paper and we
sent it off as a joint paper to Nature within a couple of days. It
was the fastest paper I've ever been involved in.

Were your research papers written solely by yourself or
were they in collaboration with others?

Oh, most of the... if my name was on a paper I think I normally
wrote it, but not always. One or two, particularly towards the
end were written by another person who was a collaborator.

In the case of collaborators, how do you assign credit for
the work done?

Well, I always tried to assign it in terms of responsibility for the
final success of the job, but it's not always that way. I mean, the
first author is always the one who has done most of the work.
After that it becomes a bit uncertain how you assign it.

Did you have any proteges?

I don't think any of our students could be described as
proteges. We've had a lot of them and a few of them have been
successful. For instance, Dick Skillizi has a chair at Leiden and
is in charge of a lot of European work, and Peter Shaver is at
Munich and has been doing some first-rate work. One of our
students, Dick Hunstead, is still with us and one of the
outstanding people on source identifications.

A number of astronomical books written by British
astronomers tend not to highlight the early discoveries
made by Australian astronomers. Is there a reason for
this?

Well, in some cases the reasons are very clear; that any books
originating from Cambridge astronomers, radioastronomers, in
view of our disagreements and public arguments with them,
were always careful about not including too much of the
Australian contributions. But in general, I think there was an
ignorance in Europe and North America of a lot of our work
because it was published in the Australian Journal of Physics,
rather than in one of the recognised astronomical journals.

Why did Australian astronomers publish mostly in the
Australian Journal of Physics, rather than in the well
known international journals? Was there a reason for this?

Well, this was very much encouraged by Pawsey among
others, mainly to help build up the Australian Journal of
Physics. We used to publish anything startling in Nature
immediately but the other journals were largely neglected. The
Astrophysical Journal had compulsory page charges at one
time and that ruled it out. Monthly Notices was the other one
and quite a lot of our papers did appear there, but not nearly as
many as appeared in the Australian Journal of Physics.

And finally what would you say is the most important
achievement in your life?

Oh well, that is a very difficult subject, but looking back - and
probably this has emotional things attached to it - my first
entry into scientific research in the early 1950s and my
development, first of a new type of interferometer and then the
Cross and the results of that. This occurred at a time when no
one really knew what radio sources were and I helped, I think,
very significantly in producing that understanding. I guess if I
had to pick out one thing it would be that time.
X-RAYS
THE AUSTRALIAN CONNECTION

JOHN R PATTERSON

Following the discovery of X-rays, physicists realized what a marvellous scientific as well as medical tool nature had placed in their hands. The creative contributions by Australian scientists to the unfolding story of X-rays over the past 100 years are highlighted in this article which brings out the human side of physics. It begins with the first demonstrations by Thomas Lyle, William Bragg and Father Joseph Slattery in early 1896, and continues to the latest 1995 development of a new phase-contrast form of X-ray imaging at CSIRO in Melbourne. On the way, it tells of the first Australian-born Nobel Laureate, Lawrence Bragg, Peter Colman’s solution of the structure of influenza protein which has led to a new vaccine, and Australia’s pioneering start to X-ray astronomy.

First Reports

News of the sensational discovery of X-rays by Wilhelm Roentgen in Germany came to Australia by cable and overland telegraph. The discovery was made on Friday evening 8th November, 1895 in the laboratory at the University of Wurzburg where Roentgen was looking for UV emissions from a discharge tube.

According to a report by Davidson, who interviewed Roentgen shortly after the discovery [1], he used black paper to cover his tube and exclude all light, and had a fluorescent screen (Barium platinum cyanide) on a table nearby, ready to be used. He excited the tube to ascertain if all light was excluded. Roentgen noticed to his surprise that the screen glowed brightly in the dark. He found he could cast shadows on the screen with various objects and expose photographic plates. In reply to the question “What did you think?”, he said simply, “I did not think, I investigated”.

He took the first X-ray photograph of his wife’s hand with a ring on 22nd December. This date goes down in medical history as the most rapid application of a new scientific discovery to medicine. He said nothing to anyone until New Year when he sent friends preprints of his paper on “A New Kind of Rays” to the Wurzburg Physico-Medical society, with X-ray pictures. He never patented the discovery which he wanted used for the benefit of humanity. The award of the first Nobel prize in 1901 gave full credit to Roentgen. Unlike subsequent recipients, he did not give a Nobel lecture and some details are sketchy [2].

In Adelaide, the SA Register carried a brief report on 31st January 1896 on p5 followed by an editorial the next day; similar reports appeared on the same day in other city dailies, e.g., the Sydney Daily Telegraph. Press reports had appeared in Vienna and London on January 5, as a result of a friend in Vienna who passed a copy of the preprint onto a newspaper friend. The English translation of the paper appeared in Nature on January 23rd 1896.

This scientific discovery was both inevitable and serendipitous. It began an intense period of modern physics. It followed experiments with cathode rays in discharge tubes by Crookes in England and Lenard in Germany, and the development of vacuum equipment and high voltage apparatus. Lenard in 1893 came closest to the discovery of X-rays when he observed some fluorescent effects near his tube which he attributed to cathode rays [3]. Their nature was not properly understood until Thomson’s discovery of the electron in 1897.

And Demonstrations

In Australia, the first X-ray photograph was taken at Melbourne University by Professor Thomas Lyle on March 3rd 1896 who had been experimenting with Crookes tubes. While he was on holidays at the beach, he saw the brief report in the newspaper and hurried back to his laboratory. As he was about

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to try his equipment, the chemistry professor appeared in the
laboratory. One of his first X-ray photographs, of the man's
foot, appeared in the "Australasian" some time later, and a
report of his success appeared in the "Argus" on 4th March
[4].

At about the same time, although the exact date is uncertain,
Father Joseph Slattery at Bathurst, NSW, produced radiographs
with apparatus he had assembled at St Stanislaus College. A
documented X-ray exists which he took of a young man's hand
in July 1896, riddled with gun shot pellets. With the aid of the
X-ray, the pellets were able to be removed and the hand saved
[4].

In Adelaide, Professor William Bragg, a popular public
lecturer, who had been at the University since 1886, on hearing
of the "invisible light" asked his Assistant Mr Arthur Rogers
to make a glass X-ray tube. (Mr Rogers later taught many physics
students glass-blowing skills, including Sir Mark Oliphant). X-
ray tubes had to be made with special lead-free glass and
highly evacuated. They had a concave aluminium cathode to
focus the electron beam onto a platinum anode angled at 45°
"to reflect the X-rays". (In fact, the significance of the
maximum radiation at 90° as evidence of the dipole emission
of electromagnetic waves was not appreciated at the time[3].
The tube was shaped with a bulge near the anode because of
the heat released there.

One of Bragg's early tubes, Figure 1, still exists in the Physics
Museum at Adelaide university, blackened by use. A cold
discharge occurred in the low residual gas pressure inside the
tube when the high voltage was applied. A reporter for the SA
Register reported seeing a pale opalescent light with streamers
from the tube (May 31, 1896). Such a discharge is only stable
at one high voltage for a given pressure. The adjustment of
such a tube required considerable care and practice. WH Bragg
later became an expert at it as acknowledged by his son,
Lawrence [5]:

"My father was supreme at handling X-ray tubes...You must
find it hard to realise in these days what brutes X-ray tubes
then were. One could not pass more than a milliamperie
through them for any length of time or the anti-cathodes got
too hot. The discharge drove the gas into the walls; one then
held a match under a little palladium tube...."

The ease of adjustment improved greatly with the invention of
the fully-evacuated, hot filament tube in 1913 by the
American, W Coolidge. However, at this time vacuum pumps
in Adelaide were primitive and Rogers' first tube was not
reliable. By a fortunate chance, Mr S Barbour, a manufacturing
chemist employed by F H Faulding, returned from Leeds with
two of the new Crookes tubes. He had difficulty with
inadequate high voltage, so he took them into the university on
a Friday night in May. In the presence of several interested
medical men and the reporter from the Register, Professor
Bragg connected them to his Ruhmkorf high voltage coil and
electric cells in the basement of the present Mitchell Building
and obtained the first clear X-ray photographs in South
Australia. He placed the film in a sealed cassette below the
tube and placed his hand on the cassette with a coin under one
finger. A copy of the resulting X-ray, donated by Sir Mark
Oliphant, is on display at Flinders Medical Centre, Figure 2. It
shows a slight injury to the little finger sustained on a farm in
his youth.

Shortly after this test, he gave one of his popular Wednesday
evening lectures in the old university library on the first floor.
of the Mitchell Building overlooking North Terrace. On this occasion, a large audience was in attendance, including the governor and Lady Buxton, whose spectacle case with spectacles became one of the objects X-rayed. By Bragg’s request, the proceeds of the lecture aided the building fund for the Students’ Union, now celebrating its centenary. During the lecture which lasted about an hour and a half, each object was exposed to the rays for about 8 minutes and the plates were then developed by the assistants.

In the meantime, Bragg enthralled his distinguished audience with his account of developments in science leading up to Roentgen's discovery and its implications for humanity. For the benefit of the many who were turned away, a fairly complete account of the lecture was given in the Register of June 1st, 1896. The lecturer talked about cathode rays and Faraday's work in electricity and gave demonstrations with a Wimshurst machine, that still exists. He showed a slide of a frog taken with the Rogers tube. A copy of a slide of Mrs Rogers' hand and neck exists. He finished his lecture by showing on the projection screen the X-rays taken that night which included a mouse in which the bones were clearly visible. An illustration of his flair as a lecturer is shown by one plate taken of a bunch of keys resting on the cassette underneath the table while a volunteer's hand was placed on top of the table over the word Rontgen in wire letters.

Patients from the hospital soon arrived to be X-rayed with Bragg's apparatus in the basement. His son Lawrence remembered when he was brought in one night at age 6 to have his fractured elbow X-rayed after a fall. Sir Lawrence wrote later [4]:

"I well remember my father's first experiments with X-ray tubes....I think I must have been amongst the first to be employed as a patient.....The flickering greenish light, crackling and the smell of ozone were sufficiently terrifying to impress the incident deeply in a child's mind."

Debate on the nature of X-rays ensued with great vigour around the world, but no further significant research was published until Barkla discovered both polarization and characteristic X-rays in 1908. JJ Thomson, in his presidential address in Liverpool to the British Association on 16th September, 1896 stated:

"If the Roentgen rays are light rays their wavelengths are of an entirely different order to those of visible light" [5].

He based this conclusion on the observed lack of refraction of the rays. In the Physics museum at Adelaide there is a sulphur prism which Bragg made to look for refraction effects and total internal reflection of X-rays, according to a later recollection by his son [6].

Bragg's research in Adelaide moved to the study of alpha particle ionization from a radium source he was able to purchase with funds of £500 provided by Sir Tom Barr Smith. Obviously, his public success with X-rays was helping him! He maintained a lively interest in the nature of X-rays but received his FRS for the alpha particle work and was then offered a new appointment to a chair of physics at Leeds. With his family, he left Adelaide in 1909, a greatly respected...
member of the University. His beautiful Australian cedar desk, which itself has an interesting story [7], is still used by the Heads of Physics. Before departing, William Lawrence Bragg received an honours BA. He later enrolled to study physics at his father’s old university, Cambridge and the Cavendish Laboratory.

X-Ray Diffraction

When WL Bragg graduated with a First in 1912, WH Bragg believed X-rays were corpuscular, despite Barkla’s work. The next great step on the path to understanding was made by Max Laue [2], a German expert in optics, after learning from Ewald, a crystallographer, that the atomic spacing in crystals was thought he only a few Angstrom units (10⁻¹⁰m). He realized that if X-ray wavelengths were as small as supposed, that X-rays must show diffraction effects with crystals - scientific sagacity at its best. His students obtained startling but very puzzling X-ray diffraction spot images from zinc blende. WH Bragg tried to explain them in terms of his own theory without much success, but he did enthuse his son with the problem during the university vacation.

Back at Cambridge, Lawrence had his brainwave and solved the problem, by realizing the spots were coherent reflections from crystal planes. He wrote down his famous equation:

$$2d \sin \theta = n \lambda$$

(This equation can be seen more elegantly now as a fundamental symmetry condition on the sphere in reciprocal space, but all that came later.) At Cambridge he set up the experiment and verified his theory with mica plates. The wave theory won out: the son proved his Dad wrong, but the two now teamed up at Leeds, combining the father’s experimental skill and the son’s wonderful intuition. They worked systematically on solving the structures of a number of simple crystals, including common salt and diamond, the latter being a particularly interesting case because of its remarkable properties.

Lawrence later described this time as like being on a gold field and finding nuggets all around. Clearly his Australian heritage was not forgotten! The following, written by him conveys the feel of that thrilling time of his life [4]: “The X-ray spectrometer opened up a new world. It proved to be a far more powerful method of analysing crystal structure than the Laue photographs which I had used....(We) worked furiously all through the summer of 1913 using the X-ray spectrometer. Although the description of this instrument was published in our joint names, I had no share in its design. ...We worked far into every night with new worlds unfolding before us in the silent laboratory.”

Sir Lawrence Bragg in 1961 looking at a plastic model of myoglobin containing 6,000 atoms. He is the first Australian born Nobel Laureate. (courtesy EH Medlin and The Advertiser)
"My father was at first far more interested in X-rays than crystals and left the determination of crystal structure to me with the exception of the paper on diamonds which showed the power of the instrument he devised. ...He measured the wavelengths of X-ray spectra and indentified them with Barkla's K and L radiations."

They were jointly awarded the Nobel prize for physics in wartime 1915, the year in which the younger brother Bob was killed at Gallipoli. William Lawrence, always Willy to his family, was the first Australian-born scientist to win the Prize and is still the youngest prize winner.

He did not return to Australia until 1961, when he visited Adelaide to give the Einstein lecture sponsored by the Australian Institute of Physics in the Bonython Hall at the University. Figure 3 shows a photograph of him at the time. He was at the height of his success with a breakthrough in the solution of the structure of myoglobin protein by his research group complete and working on haemoglobin and more complex structures. He brought with him a plastic model of myoglobin which he showed during his lecture, relating how difficult it had been to keep the stewards from sitting on it in the aircraft!

Determining molecular structure of the repeating unit which makes up the crystal structure is a more difficult problem than measuring the spacing of the lattice planes. It determines the intensities of the reflections. In the Bragg's early work it was necessary to make certain assumptions to unravel the structures of the crystals they were dealing with. For example, they assumed that the atoms were points in the lattice and the effect of each atom was proportional to the number of electrons [2].

With large molecules, more advanced methods must be used. These required a knowledge of structural chemistry to provide a trial structure. In 1951, the American chemist Pauling had come up with the basic idea of the alpha helix to describe protein molecules and this was confirmed by X-ray diffraction. The reason why such structures are important is that they lead to an understanding of how the molecules work. For example, many will be familiar with the structure of DNA, the double helix, a remarkable discovery by Crick, Watson and Wilkins in 1953 [8]. DNA is of course the fundamental genetic material. When a cell divides the strands come apart, half going into each of the new cells and providing the template to reproduce itself. Watson tells in his personal account how he was motivated by the belief that the truth when found would be simple as well as pretty.

The field has attracted some notable women scientists, of whom the best known are Kathleen Lonsdale and Dorothy Hodgkin who solved a number of important structures including penicillin, cholesterol iodide, insulin and vitamin B12 which has a metal atom (see her Obituary, Nature 371 (1994) 20. The heavy atom helps with the phase problem, which is a difficulty in complex structures, because the measurement of intensity is not sensitive to the phase of the wave.

A New Flu Vaccine

For much of this time most of the action had taken place on the other side of the world. However, in 1950, a modern crystallography group was established at Adelaide under Stan Tomlin who came from University College, London. Harry Medlin who received his PhD under Tomlin, continued the X-ray tradition and graduated PhD students who included Brian Mathews and Peter Colman in 1978.

Peter Colman, now director of the CSIRO’s Division of Molecular Biophysics, returned to Australia in 1979 and began using the powerful modern techniques he had learnt overseas to work on the molecular structure of the influenza virus surface proteins, neuraminidase and haemagglutinin. The overall structure of neuraminidase can vary enormously from one influenza strain to another, making it the 'master of disguise', and very difficult to make a universal vaccine. Dr Colman discovered, after crystallizing it and using X-ray diffraction methods, that there is a deep cavity which appeared to be present in all strains. The cavity is used in the reproduction of the virus. By targeting a specific drug, G3167, to block its activity when it leaves the host cell, the virus can be combated in all strains. The new drug was developed in association with Dr Graeme Laver of the ANU and is undergoing clinical trials. Figure 4 shows computer models of the molecular structure determined by Colman et al [9].

Phase-Contrast Images

The latest advance in the story of Australian innovative techniques with X-rays is a new phase-contrast method of imaging weakly absorbing materials, using hard X-rays, devised by scientists at CSIRO, Division of Materials Science in Melbourne [10]. Phase-contrast was devised in microscopy as a way of rendering small light path variations in highly transparent biological specimens visible. Because most biological materials are composed of carbon and other light elements, there is little X-ray absorption either in the passage of a beam through such a specimen. For the first time, the scientists have developed a high resolution contrast enhancement method, based on making the phase gradients visible by diffraction from 'perfect' silicon crystals. This method shows much promise as a way of obtaining good quality images for a low absorbed X-ray dose. Figure 5 illustrates how effective the method is with a eucalyptus leaf.

X-Ray Astronomy

Our discussion of the Australian connection with the application of X-rays would be incomplete without mentioning the pioneering work in X-ray astronomy carried out by Ken McCracken and his collaboration from the Universities of Adelaide and Tasmania between 1967 and 1969. In those days before satellites with X-ray grazing incidence imaging mirrors, McCracken's group flew a number of balloons from Mildura and rockets from Woomera. The balloon work has been continued by Ravi Sood's group at the Australian Defence Forces Academy in Canberra.

During two rocket flights in April 1967, they discovered a remarkable X-ray nova near the Southern Cross [11]. The initial brightness rivalled the first ever celestial X-ray source, Scorpius X-1 in the constellation of the Scorpion. It is now
known as Centaurus X-2. Such celestial X-ray sources are now known to be binary systems with one normal star transferring mass across to a compact companion which may be a white dwarf, or a neutron star. It is easy to imagine how such a scenario could lead to spectacular flares. A multtube collimator and scintillation detector system used for the balloon flights are also part of the Physics Museum. It is interesting to contrast this crude form of imaging with the beautiful images in 1995 taken by Rosat, the Roentgen satellite [12]. This is an accolade Roentgen would surely have appreciated!

In Retrospect

Frank Close of Oxford in a public lecture in Adelaide, to mark the occasion of the centenary of Bragg's appointment in 1986, made the following perceptive comment on the serendipity of the physicists. When Roentgen made his discovery, he could not have foreseen what the Braggs were going to do. Nor could they have foreseen how their early use of x-ray diffraction with inorganic crystals, would be applied to unravel the structures of molecules of life. At each stage unforeseen applications have been found.

Australia contributed greatly to the life of the Bragg family. William Bragg came to Adelaide as a young man of 24 and stayed until he was 47. He married the daughter of Charles Todd who built the overland telegraph. She taught him to paint, a hobby also pursued by Lawrence. The three children were born and educated here. Gwendoline Caroe has suggested that the transformation of this modest son of a farmer into a leading scientist, educator and well known spokesperson for science between the wars came about as a result of the happy, busy life he led as Professor of Mathematics and Physics at Adelaide University.

JD Bernal said of him:

"He was a great research chief, encouraging and interested without interfering and knowing how to get the best out of us and when to send us out to fend for ourselves." [5]

The physics research begun by the Braggs and which had its origins in Adelaide is one of the great achievements of 20th century science and culture. It marked out a new field, X-ray crystallography, although it is less well known to the general public than gene technology, in some sense its derivative. Both were inspiring as well as creative scientists.

After the first world war, like Abraham and Lot, father and son divided up the field between inorganic structures and organic, and Lawrence perspicaciously chose organic. In his 1961 Adelaide lecture he said that he had always had the hope of tackling the structures of the big molecules, but until the advent of the computer, which even he could not have foreseen, he did not
An X-ray phase contrast image alongside an ordinary image of a eucalyptus leaf on a scale of 6mm. (courtesy Dr SW Wilkins, CSIRO)

have the tools. What can we now look forward to in the second century of X-rays, just beginning?

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Atomic Collisions Research Alive & Well

The XIXth International Conference on the Physics of Electronic and Atomic Collisions (ICPEAC) was held between July 26th and August 1st 1995 at Whistler, British Columbia. This biennial conference, the premier meeting in the low energy atomic collisions calendar was attended by 630 delegates from over thirty countries who came together to discuss experimental and theoretical advances in the study of electron/positron, ion and photon collisions with atoms and molecules and other exotic targets. Australia was represented by its strongest ever contingent with 29 delegates (from ANU, Flinders, Griffith, Macquarie, UNSW, UWA), of which more than a third were graduate students. We also provided 4 of the invited/contributed talks and 35 contributed papers at the poster sessions.

The ICPEAC series of meetings is accompanied by a number of short "satellite" meetings on specific topics in atomic and molecular collision physics. Three of these satellite meetings were held in Berkeley, the International Symposium on Electron- and Photon Molecule Collisions and Swarms and Vancouver, Workshop on Positron Collisions; International Symposium on (e,e') Double Photoionization and Related Processes; 9th International Symposium on Polarization and Correlation in Electronic and Atomic Collisions. The Australian atomic collisions community were also well represented. At three of these meetings the Australian delegation were approximately 10% of the total) with six invited talks being presented.

The above statistics provide quantitative evidence of the healthy state of atomic collisions research in this country. The meetings themselves also provided ample evidence of the quality of these research activities with many of the international invited speakers including comparisons with both the experimental and theoretical results from the Australian research groups.

Atomic collision physics research involves both fundamental studies of scattering processes and atomic and molecular structure as well as the measurement of reaction rates and cross sections which are of direct relevance to the chemical processes that dominate our everyday lives. It is an activity which is perfectly suited to the Australian research budget and research environment and one which is second to none as a vehicle for the training of postgraduate experimental physicists. The field is alive and well in Australia and has been one of the outstanding successes of the past 25 years of physics research in this country.

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IBMM95 Conference

The ninth International Conference on Ion Beam Modification of Materials (IBMM95), chaired by JS Williams of the Australian National University was held at the ANU in Canberra, Australia, from 5 - 10 February 1995. More than 300 participants attended the conference from 33 countries. Over 420 abstracts were accepted and papers delivered in either poster or oral sessions. The location of the conference contributed to a higher than normal participation from Asia. Japan contributed the largest number of abstracts, over 60, followed by the USA, Germany and Australia. In addition to IBMM95, there were six informal supporting workshops, addressing key ion beam and materials issues, held at various locations both before and after the conference. These workshops were attended by from 30 - 50 participants and left ample time for discussion By all accounts they were both enjoyable and extremely stimulating scientifically.

IBMM95 covered all of the traditional topics of this conference series but highlighted specific areas of either particular relevance to the Australian research effort or were topical internationally. Major topic areas included:

- Basic ion interactions; low energy processes; defects in semiconductors; high fluence implantation and phase formation; applications in electronics;
- Optoelectronics; ion beam modification of non-semiconductors and novel ion beam equipment and techniques.

The conference was organised into 15 oral sessions, including three plenary presentations covering areas of general interest, 22 specialist invited papers and 51 contributed oral presentations as well as three poster sessions. There were several scientific highlights covering a diverse spectrum of materials and ion beam processing methods. These included a wide range of both conventional and novel applications of ion beams such as: optical displays and optoelectronics, motor vehicle and tooling parts, coatings tailored for desired properties, studies of fundamental defect properties, the production of novel (often buried) compounds, and treating biomedical materials. The study of nanocrystals produced by ion implantation in a range of host matrices (plenary paper by HH Andersen, Denmark) of optoelectronics applications (as indicated in a paper by HA Atwater, Caltech) I, was one especially new and exciting development. Despite several decades of study, major progress was reported at the conference in understanding defect evolution in semiconductors and the role of defects in transient impurity diffusion. A complete oral session was devoted to this topic, led by an invited presentation from DJ Eaglesham, AT&T. The use of implantation to tune or isolate optical devices and in forming optically active centres and waveguides in semiconductors (S Coffa, Catania), polymers and oxide ceramics (A Polman, FOM) was a major focus of several presentations at the conference. The combined use of ion beam methods and more conventional means of growing and modifying buried compounds and 3-dimensional layered structures featured prominently, the main progress was excellently reviewed in the plenary paper of S Mantl, Julich. The formation of hard coatings by ion assisted deposition or direct implantation (D McKenzie, Sydney and JCBarbour, Sandia) was also an area which showed much recent progress. Ion beam techniques had also developed as apace, particularly those based on plasma immersion ion implantation or alternative techniques for large area surface treatment (such as papers by J Conrad, Wisconsin and IG Brown, Berkeley) Finally, the use of ion beams for the direct treatment of cancers (Tape Chung, Singapore) was also a particularly novel and interesting application of ion beams.

Despite the heavy scientific program, the atmosphere was relaxed and informal. The early afternoons of most conference days were left free to stimulate interaction between participants both scientifically and socially. The social program included a wine and cheese reception, an evening barbecue and a meeting of the Bohmische Physikalische Gesellschaft at which a presentation was given on the origins of the first Australians. In addition, there were conference outings to a little Australian and a conference banquet held in the Great Hall of the Australian Parliament House. In addition to several private and sponsorship activities, the Australian Materials Research Society co-sponsored the conference.

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Women in Physics

Workshop for Women Physics Students at Melbourne University

It is widely recognised that women are substantially under represented in the physical sciences. A world wide study of university departments showed that in Australia, although 29% of the first year students, with a declared intention of majoring in physics, were women, this had dropped to 17% by third year. Furthermore, only 6% of PhD students in physics are women. One of the most striking features is the substantial drop in the percentage of women students at every level. Last year the School of Physics at Melbourne University was awarded a grant from the equity initiatives fund administered by the University Equal Opportunity Unit to run programs aimed at improving the retention of 3rd year students into the Honours programs, and at encouraging female students to enrol in higher degrees. These programs would also provide support for current postgraduate students.

Given the lack of confidence and often isolation that female physics students usually experience, one of the desired outcomes of this program was improving communication between women students at various stages of their degrees and women staff.

Astronomy

Two telescopes were taken out to Blackwood. Despite the cold but clear weather, everyone had a good view of Saturn on the first evening.

Physics in Industry

Andrea Pidcock, a Senior Research Physicist at CRA Advanced Technical Development, was invited to attend to provide the perspective of a physicist working in industry. She discussed her education, a Physics Honours degree and a degree in Electrical Engineering from the University of Sydney. Andrea was surprised during an engineering recruitment exercise to be hired by CRA as a physicist. She described the diversity of her duties (project management, basic research), the CRA career path and CRA recruitment practices. Andrea emphasised the importance of the honours degree in obtaining an industrial position, since 4th year was the only time that a relatively independent research project was undertaken. The possibility of industrial researchers being paid while completing a higher degree was mentioned. The importance and the value of vacation work was emphasised, as were the mechanisms by which CRA, and other companies, recruit graduates for full time positions.

Gender Issues in Physics

This was a very informal session. Firstly, the staff asked for the undergraduate’s opinions on whether they had been singled out, or made to feel uncomfortable, because of their gender. They agreed that, although they had been annoyed when singled out as the only woman in a particular group, it had not particularly discouraged them from continuing in physics. Sexist jokes by lecturers tended to be dismissed. When asked who had been educated at single sex, ie girls, high schools, two thirds responded that they had. Opinions varied as to the advantages or otherwise of such an educational environment. However, there seemed to be almost universal agreement about the problem of feeling inadequate and lacking confidence in their own ability. The staff present commented that they had had to consciously ignore negative feelings about their own abilities.

Planning a Career in Physics

Staff discussed their varying career paths to becoming a lecturer and emphasised the fact that there is no unique way of ultimately pursuing the one career and pointed out that all three women lecturers in the School have had very different career paths. The relative merits of taking a break and thinking more consciously about undertaking a higher degree were discussed and the importance of negotiating expectations with employers, or postgraduate supervisors, was emphasised. The large variety of careers undertaken by physics graduates was mentioned as were approximate starting salaries of graduates. The problems of the ‘dual-career’ couple were mentioned with several examples of how this could be managed when mobility was important and appropriate positions few.

Postgraduate Study in Physics

The various paths leading to higher degrees were discussed. Although the Honours program in Physics at Melbourne University is extremely challenging, current third year students were advised to overcome their lack of confidence and attempt fourth year if their third year results were adequate. Aspects of different higher degrees were discussed. The issue of supervision was raised and the best way to choose and subsequently negotiate with a supervisor was discussed. The benefits of talking to postgraduate students working in various research groups was emphasised as a means of obtaining information about the group. Finally, the pros and cons of attempting a PhD overseas were discussed.

Evaluation

The informal response to the weekend was that it was extremely successful.
Many said that they were now more confident about attempting Honours and a higher degree. The results of questionnaires suggested that the students had gained valuable information and most stressed the fact that meeting postgraduate students and staff in a less formal environment was extremely useful. The timing of the weekend was agreed to be good and there were suggestions that it should become an annual event. The students were also extremely impressed by Andrea Pidgeon and expressed a desire to meet more women physicists who were working outside universities.

My favourite comment, however, was from the student who suggested that we should "Bring some boys to do the cleaning and chop the wood." Since one of the main aims of these activities is to increase the percentage of women continuing into higher degrees, it is difficult at this stage to assess their long term success. Nine women are currently enrolled in Physics Honours at the University of Melbourne in 1995, out of a total of 24, which is a record. The weekend workshop will be held again in September of this year, and there is a great deal of optimism about the long-term benefits of such activities.

Postscript

This year at the Australian National University, there are 5 women and 1 man doing Physics honours. This is an unusual year for Physics, with typical numbers being around 30% women and 70% men. Apparently, this is not the result of any specific recruitment drive or particular activities.

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Product News

Brushless Servo Motors

Aerotech's Powerflex series of brushless servo motors offer a breakthrough combination of price and performance. These new brushless motors provide up to 50% more torque, 15 times the acceleration, 33% shorter length, and 20% lower price than brush DC services of the same frame size. And the Powerflex series require no maintenance so they are ideal for a wide range of special production machine, medical equipment, assembly and inspection equipment.

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High Performance Data Acquisition Boards Optimised for Windows

Includes Free Windows Data Acquisition Software

ADAC's new S800 Series is a line of four multifunction data acquisition boards optimised for running in a Windows environment. Priced far below competing "Windows" plug-in boards, the S800 Series is a complete Windows hardware and software product. Windows-specific hardware features for high performance data acquisition include dual DMA, a 1024 Word FIFO, and onboard RAM for channel gain list storage. Software consists of DIRECTVIEW for Windows (DVW); a high speed data acquisition package that includes board set up software and tutorial, as well as a complete user manual as an interactive Windows help system. DVW provides "plug-and-play" ease in non-plug and play PC's. The S800 Series has the following features:

- Complete Software Set Up
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- Multiple Triggering Modes
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- Dual 16 bit DAC option
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Windows Optimisation

The S800 Series includes a 1024 word P
FIFO, a hardware necessity for data acquisition under Windows. While the PC's interrupt service routine (ISR) is executing during an application, the 5800 Series temporarily stores data in the FIFO, allowing for time required to reprogram both the DMA controller and the hardware device registers on the board. Without a FIFO, data sampled by an A/D board during reprogramming would be lost. Therefore, a FIFO is essential for gap free high speed collection of data under Windows.

Windows' handling of interrupts further complicates things when an application calls for different gains (or input ranges) selected on a per channel basis. The 5800 Series' on-board channel gain list (stored in RAM) allows all gain switches to occur in the background. Any other method of providing a channel gain list would require software intervention - which would severely limit the acquisition rate due to interrupt latency. Not only does the channel gain RAM provide a convenient method of setting the input gain on a per-channel basis, but it also allows the user to specify input gains during high DMA data acquisition.

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The 5800 Series ships complete with a free copy of ADAC's DIRECT VIEW for Windows board tutorial and data acquisition software. DIRECT VIEW for Windows (DVW) is a unique interactive program that guides the user through complete board setup, user wiring connections, and board operation. After board setup, DVW performs high speed data collection, display, and streaming to disk - all without any programming. In addition, DVW contains an interactive help system that includes the complete 5800 manual.

For users who wish to write custom programs, the 5800 Series can be purchased with ADAC's $95 ADLIB WIN for programming under Windows or with ADAC's $50 ADLIB PC DOS drivers for programming under DOS. In addition, the 5800 Series is compatible with the following popular software packages:

- Test Point
- Lab Tech Notebook and LT/Control
- DriverLink
- Snap-Master
- Genesis

Accessories

The 5800 Series can be purchased with a passive screw terminal panel (model TB5800-16) for connecting to all of the I/O on the card. An optional low-cost thermocouple panel (model TB5800-TC) that provides 16 thermocouple inputs, as well as a low-cost optional multiplexing panel (model TB5800-64) that expands the number of A/D inputs to 64 are available.

For further information contact:
SciTech Pty Ltd
155 Plenty Road
Preston South VIC 3072
Tel (03) 480 4999, fax (03) 416 9959

Newport's New MM3000 Motion Controller/Driver

The Motion Master 3000 (MM3000) is a cost effective and convenient means of controlling as many as four Newport motion control stages or motors. Drivers are available for use with DC servo motors up to 200 Watts/axis (500 Watts total) or stepper motors up to 100x

The system offers improved overall positioning performance with exceptional repeatability. MM3000 features include:

- Closed-loop mini-stepping
- Automatic power cut-off on error
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- Compatibility with all Newport DC and stepper motors and stages
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- Options joystick control

Operation is simple and intuitive, with large LED displays and separate jog, reset, and home buttons dedicated to each axis. From the front panel, users can execute motion programs stored in non-volatile memory, initiate manual jogs or automatic moves, perform home searches, configure axis operating parameters, and perform diagnostic tests.

Complex motion sequence programming is simplified through use of the Motion Master command set, which consists of over 100 two-character mnemonic commands.

For more information please contact
Neil McElhinney or Matt Hannifin at:
Coherent Scientific Pty Ltd
116 Burbridge Road
Hilton SA 5033
Tel (08) 352 1111, fax (08) 352 2020
Internet: 100351.1471@compuserve.com

New XY PZT Stages With Capacity Sensors Guarantee Subnanometer Accuracy

The new Physik Instrumente P-730 and PI-731 monolithic XY piezoelectrically driven, EDM cut flexure stages offer 50x50 and 100x100µm motion ranges, respectively. Model P-730.20 boasts 3µm-Nanometer accuracy. Resonant frequency of 400 Hz allows fast scanning. Basic models are offered in aluminium; other materials including stainless steel and Invar are also available. Open loop, LVDT (Linear Variable Differential Transformer) and CAPACITIVE displacement sensor versions are offered. These high precision stages find use in near field scanning microscopy, X-ray scanning microscopy, atomic force microscopy, precision mask and semiconductor wafer alignment and other applications.
where single plane, high precision XY motion is required.

For further information, contact
Derek Huxley at Warnash Pty Ltd
Tel (02) 319 0122, fax (02) 318 2192

PRODUCT NEWS

Axum for Windows is First to Offer Drag-and-Drop Technical Graphics

TriMetrix Inc has recently released Axum 4.0 for Windows, the first drag-and-drop technical graphics and data analysis package. Based on the award-winning Axum for DOS, Axum 4.0 for Windows allows users to create publication-quality technical graphs without the ease they are accustomed to in the best-selling Windows business graphics packages. With Axum 4.0 for Windows, users can create graphs instantly by dropping data onto 2D and 3D plot buttons. This interactive, graphical approach makes it easier for users to create and edit graphs, and to switch between different graph types quickly. For example, to add a second series of data to an existing bar chart, users can simply drag the additional data column and drop it onto the bar chart - additional bars are drawn instantly.

With Axum 4.0 for Windows, users get many "Windows 95" features while running under Windows 3.1 today: OLE 2, drag-and-drop, multi-threading, object-oriented, desktop, and menu bar. Axum 4.0 for Windows offers all of the powerful 2D and 3D graphing capabilities and data analysis features that made Axum for DOS such a popular choice among scientists and engineers. Users can work with virtually unlimited-sized data sets, perform a variety of statistical analyses, and do smoothing and curve fitting.

For more information contact, Graeme Jones at
Lastek Pty Ltd, Canberra Branch
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Tel (06) 258 0444, fax (06) 258 0445

New WaveMeter Brochure From Burleigh Instruments

Burleigh Instruments Inc (Rochester, New York) has released a new 14 page brochure describing its range of wavelength meters.

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Guide For Spectroscopy

The new Guide for Spectroscopy from Spec/JY is now available.

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For a copy of this guide please contact Dr Paul Wardill or Teresa Rosenzweig at:
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OBITUARY

JEORFREY COURTNEY-PRATT

1920-1995

I hope that this will draw your attention to the life and achievements of a remarkable expatriate Australian, one of those rare breed of original thinkers who have left our shores, part of a brain drain which does not appear in government statistics.

Most of you will not have known Geoffrey Courtney-Pratt, who began his research career with CSIRO (then CSIR) during World War II and later moved to Cambridge and then to Bell Laboratories. He achieved many honours for his work in high speed photography and other optical techniques. I had the pleasure of meeting him during a visit to Murray Hill in 1965-66 and on later occasions.

He was born and schooled in Hobart, earning a BE degree at the University of Tasmania and then joined the Lubricants and Bearings Section of CSIR (now Australian National University and later to become the Division of Tri-bophysics) led by another Tasmanian, Philip Bowden, and including David Tabor and Hill Worner. Their contribution to manufacturing industry and defence supplies was essential to the war effort. In 1944 Courtney-Pratt was seconded to the Admiralty in Britain to use his photographic skill to measure velocities of naval projectiles. After the war he moved to Cambridge University to join Professor Bowden in the Laboratory for Physics and Chemistry of Solids and pursued high-speed photography and multiple-beam interferometry, gaining his PhD in 1949. He stayed at Cambridge as a Fellow of Caius College and as Assistant Director of Research, continuing work on surfaces and molecular layers. He was awarded the Charles Vernon Boys’ Prize of The Physical Society of London in 1954 and DSc of Cambridge in 1958. He was also elected a Fellow of the Royal Photographic Society and awarded the Gold Medal of the Photographic Society of Vienna.

Marrying in late 1957, he and Gillian moved to Murray Hill, New Jersey in April of 1958 when he joined the Mechanics Research Department of Bell Labs, headed then by Warren Mason and including other major “acousticians” such as McSkimin, Thurston and Orson Anderson. Geoffrey succeeded Mason as head of the group which moved to the Holmdel site in 1967 and underwent occasional name changes as is fashionable in modern science.

This department did a lot of the pioneer work associated with information technologies, including fibre optics, voice switching, echo reduction, picture coding for transmission of colour images, liquid crystal displays and electronic blackboards. Geoffrey continued his own research on high speed photography, optical masers, holography optical methods for measuring satellites and fundamentals of surfaces.

He was recognised by many further awards from the Optical Society of America (Fellowship), the Society of Motion Pictures and Television Engineers (Fellowship and DuPont Gold Medal), The Society of Photographic Instrumentation Engineers (Fellowship and Alan Gordon Award) etc. As well as many research papers he had over 30 patents to his credit before retiring from Bell in 1985 and establishing a small consulting company.

I am afraid that this catalogue of achievements does not reveal his breadth and humour nor do justice to his skill in inspiring his colleagues nor his originality and ability as a lateral thinker. He was a physicist plus engineer and a person of whom Australia can be proud.

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My thanks to his sister, Mrs Joan Coates of Kew, Victoria for the photograph and biographical notes.
reviews

Prompt Critical

Physics Catches the Criminals

Next to Mills and Boon romances, crime novels are top sellers. Most of us seem to enjoy a good 'whodunit' mystery, where a trail of clues leads to the culprit. The clues in Sherlock Holmes' day were often subtle, but always easy to comprehend, at least in their scientific dimension. Nowadays deep science is frequently involved in forensic investigations, especially the use of physical principles unfamiliar to the average person, let alone the lawyers!

Books on forensic science tend to be weighty tome addressed to specialists. There are few expositions of the subject suitable for those untrained in science. However a Canadian physics professor, Dr Brian Kaye, has published a volume titled Science and the Detective aimed at non-science university students as an introduction to science, sucking them in through the appeal of its subject matter. Notwithstanding its target readership, there will be few physicists who will fail to learn more about their discipline from this book.

One aspect well brought out by Science and the Detective concerns expert witnesses. Physicists take care! Pseudo-science can be dangerous. It is an axiom in the financial arena that bad money always drives out good money. It can be the same with science in the courts of law. Dr Kaye quotes Law Professor George Levi "No matter how many respected scientists the defence brings in, the plaintiff needs only one fringe scientist to sow enough doubt in the jury's mind to allow them to find for the plaintiff." So beware. Later in the book Dr Kaye returns to the theme of fraud in science and delivers a further quote "Anytime you have countervailing expert testimony you have got trouble."

For an example, look no further than the current C.Simpson trial.

I found lots of interesting cases and material in Science and the Detective but I have to report that the book bears a number of clues pointing to hasty preparation. There are many errors of spelling (such as 'Isle of White' instead of 'Wight', and 'Desraille instead of 'Disraille'), grammar, punctuation, wrong usage of words (such as 'adsorption instead of absorption'), wrong or duplicated captions, and the odd non sequitor. I'm not sure how "chemicals are carried through the respiratory system to the bladder", but I'm not a biologist. Apart from these textual problems, which I trust will be rectified in a future edition, the book is well produced by the publisher on good paper with a sturdy soft binding.

The author confesses that one of his hobbies is etymology and dictionaries. He liberally sprinkles the text with definitions and word meanings, most of which would have been better put in a glossary. The indexing and references are adequate, although the latter lean heavily on the New Scientist and newspaper stories.

All things considered, I found Science and the Detective enjoyable reading for the insights and explanations it gave me for many of the historical and news events I had wondered about. It is a book that can be dipped into whenever you feel like something different.

Science and the Detective by Brian H Kaye is published by VCH Publishers, Weinheim with 388 pages in soft cloth covers for DM68, and has the ISBN 3-527-29252-7. Librarians will find it a popular selection for their shelves.

Colin Keay
Reviews Editor

Reviews

Theory of Electron-Atom Collisions Part 1: Potential Scattering

PG Burke and CJ Joachim
xi + 255pp, A$97 (hardcover)

This volume is the first in a three part series aiming to provide a comprehensive overview of electron-atom and electron-ion scattering. I found the 255 page volume (of which 54 pages are Appendices, references and the index) which was restricted to potential scattering, to be a rather pedestrian effort with some glaring omissions.

Firstly, it is incredible that the authors did not mention that it is possible to solve the Lippmann-Schwinger equation numerically. This equation provides the basis of most high energy approximation methods, and has been successfully used by many authors to solve some extremely taxing scattering problems. That the authors decided to waste almost 20 pages on the Eikonal-Born-Series type of approach I found equally incredible.

The treatment of low energy scattering in the presence of long range potentials was careless. The authors present an expression for the low energy behaviour of the cross section without mentioning that for precise work it is much better to use the equivalent expression for the phase shift (and then square it).

Furthermore, the scattering length quoted for argon is incorrect. Given that it is now only five years from the next millennium, I thought that some concession could have been made to the computer. Some description of the procedure usually used in potential scattering, numerical integration followed by normalisation at large distances would have been appropriate.

One of the more pleasing aspects was inclusion of material on potential scattering based on the Dirac equation. However, the description was restricted to neutral targets and omitted any mention of the boundary conditions for charged targets. In addition there was no description of techniques that could be used to solve the Dirac equation (eg for the R-matrix method).

There were some other omissions, the two-potential theorem of Gellman and Goldberger, a description of the high-energy behaviour of the phase shifts, and suitable material on the properties of Coulomb functions.

To summarize, at a cost of $97 this is a disappointing volume. Most of the material included is treated adequately, but the volume is somewhat narrow in scope and I would not recommend this volume as a purchase for individuals or for libraries.

J Mitroy
Faculty of Science
NTU Darwin

Electron-Atomic Collisions

Ian E McCarthy & Erich Weigold
xii + 328pp, A$150 (hardcover)
ISBN: 0-521-41359-1

Practitioners in the field of electron-atomic collisions will feel a resonant response with the author's introductory comment that "the interaction of electrons with atoms is the field that most deeply probes the structure and reaction dynamics of a many-body system." Other readers will be convinced of the claim by the very

228 Australian & New Zealand Physicist Volume 32, Number 10, October 1995
persuasive arguments, excellent theoretical and experimental evidence and the clear presentation. The authors, McCarthy, the theorist and Weigold, the experimentalist, have established a large part of their international reputation through an 'iterative interaction' of theoretical and experimental physics. Their text will be a long-standing tribute to their achievements as it successfully imparts their methodology and deep understanding of their field. The presentation of that information in a text fills a void in the literature.

The style of writing is direct and clear. The text aims to teach, to facilitate learning and to develop the scientific method. There are frequent statements such as ‘...this gives information...’ and ‘...this means...’ which help to clarify the link between the mathematics and the observations as well as providing a sounder physical understanding of the atomic structure and collisions. This approach was established early in the text and will capture the readers' attention till the last page.

The text moves gradually at first with a guide to modern experimental techniques and then the pace quickens with a substantial and thorough treatment of relevant quantum theory. The discussion of the choice of coordinate frames and basis sets is most apt. The reader with a good previous course in basic quantum mechanics will follow readily the sequential steps of the first eighty pages of fundamental quantum mechanics in which one electron problems are described. But the authors do more than describe the bound states solutions for an electron in different local, central potentials and the scattering of an electron from those potentials. Since scattering experiments measure momenta, not positions, they show how the potential scattering problem, first defined with the Schrodinger differential equation in coordinate space, can be written as a natural occurring integral equation in momentum space. They show why this approach makes it much easier to see the physics of the scattering and makes the calculations easier. They show how the lower-energy eigenstates of an atomic system can be represented by an M-dimensional square-integrable basis for each symmetry manifold and show why a complete set of atomic states must include the ionisation continuum. After the formal scattering theoretical aspects have been covered, the calculation of scattering amplitudes is pursued and the ways of approximating the physical infinity of states using the convergent close-coupling and coupled-channels optical methods are displayed. The text also shows how structure calculations are done and gives the details of the different forms that can be adapted to reaction calculations.

Dedicated students will have worked through the first seven chapters during the course of their postgraduate studies. A browser will benefit from the excellent introduction to each chapter which gives much physical meaning to the following mathematics. As you read on, you will be richly rewarded by seeing the reasons for the design of many experiments and by a deeper understanding of experimental data. For example, an excellent presentation is given of the way in which both theory and measurement have defined excited and ionised atomic states and how the electron charge clouds and their angular momentum transfer are characterised. Advances in the theory have enabled the preparation of state-selected particles, in particular spin-polarised electrons and atoms, so it is now possible, almost routinely, to explore the effects of relativistic spin-dependent interactions, such as the exchange and spin-orbit interactions, which are much weaker than with the Coulomb interaction. The text gives a thorough description of the physical principles and recent observations. The last two chapters deal with ionisation phenomena and electron momentum spectroscopy. Here the three-body final state allows a wide range of scattering kinematics to be investigated and information can be obtained on the single particle structure, the electron correlations of the target atoms and residual ionic states. At this stage of the text there is again a strong enforcement of why an understanding of structure and reactions is achieved iteratively. The authors state "a theoretical description of a reaction is completely tested only when we know the structure of the relevant target states with an accuracy that is at least commensurate with that of the reaction calculation". There are many good references to guide the reader through the historical evidence for that statement.

In summary, the text generally follows the published research works of the authors and presents an excellent account of many of their achievements. The success of the convergent close-coupling method in describing many observations in electron-atom collisions is well described. After mastering the text the reader will be well placed to understand current research in both experiment and theory. Also the foundations have been provided to extend the methodology to the study of electron-molecule collisions and then to the electronic properties of molecular centres in condensed matter physics, chemistry and biology.

If one wanted to expand the text then inclusion of more experimental data would be welcome. For example, there are spectroscopic studies of heavier atoms, collisions in the presence of external fields and low energy asymmetric near-threshold studies of ionisation.

The cost of the book is exorbitant which is unfortunate because it deserves a place on the bookshelf of every collision physicist and student of the subject. The text is eminently suitable as a textbook and I shall certainly use it for an honours and postgraduate course for some years.

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Distributions, Ultradistributions and Other Generalised Functions

RF Hoskins and J Sousa Pinto
Ellis Horwood, 1994
ix + 300 pp., £60.00 (hardcover)

At a slim 300 pages, this book is a mine of information. It would be of great interest and utility to anyone who required more than the usual "first introductions" to generalised functions. There are six chapters of almost equal length.

Chapter 1 deals with introductory ideas as developed by Schwartz, also generalised powers and principal values, together with a brief discussion of other approaches to the theory.

Chapter 2 is concerned with some of the remarkable properties of distributions. There is also a discussion of the place of the well known books by J Lighthill and DS Jones in the picture.

Chapter 3 deals with Fourier Analysis, Chapter 4 with Analytic representations. These chapters are the core of the work, and contain a wealth of information about Fourier transforms, various classes of generalised functions, ultradistributions,
Monolithic Diode-Laser Arrays

NW Carlson
Springer-Verlag, Berlin 1994
xii + 369pp., DM98 (hardcover)
ISBN 3-540-57910-9

Dr Carlson's stated goal is to give a unified presentation of physical principles, optical design, operating characteristics and ultimate performance projections of monolithic diode-laser arrays for single mode, high powered operation. He has produced a very comprehensive review of the research literature which is of great value to the specialist in laser diode technology. The first chapter on the history of the laser diode arrays refers references nearly 500 articles dating from the first diode laser papers in 1962 to 1993. The reader with a general interest in lasers would probably prefer more synthesis in this review.

The chapters aiming to give a unified presentation of the background physics are variable in achieving this goal. The fundamentals of high-powered laser-diode operation are dealt with fully but as the book progresses to chapters on mode discrimination and theoretical modelling of monolithic diode laser arrays it reverts to being a documentation of current research more than it is a tutorial review. It maintains its comprehensive coverage of all the fronts on which research is progressing.

The final chapters give very detailed descriptions of all the significant device architectures for diode-laser arrays under active development. This is of interest to the general reader in the area of lasers as well as the specialist.

Dr Carlson gives interesting insights into how development in semiconductor fabrication technology have made feasible new laser-diode array architectures. The book will be most useful to those wanting an introduction to the research literature on laser-diode arrays or an overview of important device architectures.

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Conversations on Mind, Matter and Mathematics

Jean-Pierre Changeux & Alain Connes (edited and translated by MB DeBovoise)
xii + 260pp., US$24.95 (hardcover)
ISBN 0-691-08739-8

On the face of it, this ought to be a thoroughly unfashionable book. For one thing, it is in dialogue form, and scientific dialogues ceased to be common many years ago. For another, the two scientists involved are French, and France is decidedly unpopular in our part of the world at present.

For physicists, there is a further problem: neither of the two scientists is a physicist. One is a neurobiologist, the other a geometer. There is little research which directly involves both biology and mathematics (as opposed to statistics) and I often wished for someone from another discipline to plug the yawning gap between the two.

Having said all that, the book is interesting. Both men are world-ranked scientists, and members of the French Academy of Sciences. Both have thought deeply about their work. And they touch on some very important issues. One, which keeps coming up throughout the book is, the question of whether mathematical reality exists independently of human minds. Changeux thinks that mathematics is purely a construction of the human mind. Connes, from years of running up against the immovable logic of the subject, believes strongly that mathematics is real.

Both men have intriguing things to say about the stages of discovery and imagination in science. They try - not very convincingly, in my opinion - to relate progress in mathematics to a kind of mental Darwinism. With more conviction they relate problem-solving to pleasure and pain, comparing moments of religious ecstasy, artistic pleasure and mathematical illumination.

Both men give examples from their own fields to illustrate their points. Personally, I found these examples so terse as to be unhelpful, whether it is Connes talking about P-adic numbers or Changeux about response-speciality of neurons.

The final section, on ethics, is a bogus dialogue. Changeux writes a short paper on the topic, and Connes gives a brief reply. Changeux tries to link ethics to evolution and aesthetics, making a few side-swipes at religion and racial prejudice.

So would physicist find this book worth reading? Well, if issues of mind and mathematics appeal, then by all means give it a try. At the very least, it is interesting to compare one's own views on some profound matters with two very acute - and very French - thinkers.

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Higher Superstition. The Academic Left and its Quarrels with Science

Paul Gross and Norman Levitt
The John Hopkins University Press
Baltimore and London 1994
ix 314pp., US$55 (hardcover)

Physicist might wonder what on earth this book has to do with them. It isn't written by a physicist, but by a mathematician and a biologist. And it is about developments in some parts of the humanities and social sciences. So why not shrug the shoulders and get on with something else?

There are good reasons why all scientists, including physicists, should read Higher Superstition. It highlights a current of profound hostility to science in parts of academia. What’s more, argue Gross and Levitt, unless this current is reversed, academic science could be endangered.

The authors range across a good deal of territory, but two ideas are vital. First, they argue that academia is the home of the Academic Left. This is the remnant of the radical movements of the 1960s, now without a mass following. In reaction, some of these academics have...
adopted an approach which Gross and Levitt term "perspectivism". Essentially this argues that science is merely one of a whole range of possible perspectives, and that it is particularly associated with white western male dominance. Hence, being left-wingers, they believe that other viewpoints deserve a say. These include feminism, environmentalism and various ethnic viewpoints. The key point, though, is to dethrone science from its privileged position.

Of course, if perspectivism ever becomes universally accepted, science will be in terrible trouble. There will be no way of telling good ideas from bad ones, nor the rankest kind of pseudo-science from genuine knowledge: they are all just the perspectives of different groups!

Gross and Levitt have no trouble demonstrating a pathetic degree of ignorance among many of these critics of science. They also point out that many have risen to fairly high academic positions on the basis of remarkably poor work. They suggest that scientists should make a practice of turning up at seminars given by science-bashers and registering dissent. This is logical, though it condemns many scientists to endless hours of frustrating boredom; practitioners of the higher superstition seem unwilling to use one clear word where three baffling ones will do.

Higher Superstition casts a searchlight into an area where, I suspect, few physicists care to tread. It is well-written, fascinating book. Have a dictionary at hand, though, as Gross and Levitt are fond of long Latin-derived words.

Martin Bridgstock
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New Books

The Properties of Optical Glass
H Bach & N Neuroth (eds)
Springer-Verlag, Berlin 1995
xvii + 410pp., DM268 (hardcover)
ISBN 3-540-58357-2

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SV Biryukov et al
Springer-Verlag, Berlin 1995
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ISBN 3-540-58460-9

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L Reimer (ed)
Springer-Verlag, Berlin 1995
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ISBN 3-540-58479-x

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IH Sloan & S Joe
xi + 239pp., AS$5.00 (hardcover)
ISBN 0-19-853472-8

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E Fermi
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JM Knudsen & PG Hjorth
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xvi + 413pp., DM148 (softcover)
ISBN 3-540-58364-5
CONFERENCES & MEETINGS

1995

October 30 - 31 ANA 95, Nuclear Science & Engineering in Australia 1995, Lucas Heights NSW Hosted by the Australian Nuclear Association Inc. in association with the Australian Institute of Nuclear Science & Engineering (AINSE) and the Nuclear Panel of The Institution of Engineers, Australia. Contact: Conference Manager, ANA 95, AINSE, Building 5, Private Mail Bag 1, Menai NSW 2234. Tel (02) 717 3376, fax (02) 717 9268

November 14 - 17 The Australasia-Asia 1995 XPS Symposium, Sydney, Australia. Contact Dr Paul Pigram / Amanda Riley, Chemistry UNSW, Sydney NSW 2052. Tel (02) 385 4645, fax (02) 662 1697, email XPS1995@guq.chem.unsw.edu.au

November 20 - 24 Engineering and Physical Science in Medicine Conference '95 & 3rd Asia/Pacific Regional Conference of the IEEE Engineering in Medicine and Biology Society Queenstown, New Zealand. Contact Conference Secretariat, Centre for Continuing Education, University of Canterbury, Private Bag 4800, Christchurch New Zealand. Tel (64) (3) 364 2162, fax (64) (3) 364 2057, email m.brown@ccc.canterbury.ac.nz

November 27 - 29 The 9th Australian Conference on Nuclear Techniques of Analysis and 3rd Vacuum Society of Australia Congress, University of Newcastle, Australia. Contact Assoc/Prof J.D. O'Connell, Department of Physics, University of Newcastle NSW 2308. Tel (049) 21 5439, fax (049) 21 6907, email phjoc@cc.newcastle.edu.au

1996

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, RCJTA, URSI Contact Prof DB Melrose, RCJTA, School of Physics, University of Sydney NSW 2006. Tel (02) 351 2542, fax (02) 660 2903, email iau@physics.usyd.edu.au, WWW: http://www.physics.usyd.edu.au/iau160.html

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 (8) 302 3244, fax (8) 302 3389, email phabw@levels.unisa.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 http://www.utas.edu.au/docs/physics/AIP/Congress for additional details. Contact (accommodation and registration) ApplePhys'96, Mures Convention Management, Victoria Dock, Hobart TAS Australia 7000. Tel (002) 34 1424, email mures@hba.trumnet.com.au, Contact (scientific program) Prof R Delbourgo, Physics department, University of Tasmania, GPO Box 252C, Hobart Australia 7001. Tel (002) 30 2403, email Bob.Delbourgo@phys.utas.edu.au

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