Award of 'Founding and Life Fellow of IRPS' grade to Dudley Creagh and David Bradley

Adjunct Honorary Distinguished Professor Applied Physics and Radiation Technologies Group Sunway University

Professor Emeritus Centre for Nuclear and Radiation Physics Department of Physics, University of Surrey

Honorary Professor University College London

David A Bradley PhD (USM), MSc (London), BSc (Essex), F.Inst P., FIPEM; Promoted to Professor on 1st April, 2010; Professor Emeritus University of Surrey; previously Head of the Centre for Applied Physics and Radiation Technologies at Sunway University. During his career he has been Secretary of the International Radiation Physics Society (IRPS), and President 2018-2021.

He was Editor-in-Chief for some years of Applied Radiation and Isotopes and subsequently RPC; and he was also for a term of three years Editor-in-Chief (Scientific) of the British Journal of Radiology, the worlds' oldest journal of Radiology (with an initial name 'The Journal of Skiagraphy - directly from the Greek, meaning the casting of shadows).

His interests in the fundamentals of radiation interactions have turned to applications in biomedical areas and industry, taking in development of luminescence dosimeters. Supervision of some 30 PhD students and 5 postdoctoral research associates has engendered a number of collaborations. He has been cited over 15500 times and has a h-index of 59. For example, he was cited 2160 time in 2024 alone [Google Scholar].

Professor Bradley has an established standing in the field of applied nuclear and radiation physics. His work has also led to a number of commercial applications, with contributions that have underpinned the formation of two University spin-out companies, TrueInvivo Ltd in the UK and Lumisyns Sdn. Bhd. in Malaysia, both developing luminescence systems for medical dosimetry.

Professor Bradley has held several major international roles: Member of the British Standards Institute (BSI) NCE/2 Radiation Protection and Measurement Group and the Protect Team PT 62945 project Computed Tomography (CT) Security-Screening Systems; Member of Board of Directors of The International Centre for Environmental and Nuclear Sciences (ICENS), University of the West Indies. Professor Bradley has also been the recipient of a number of international awards including the Institute of Physics and Engineering in Medicine (IPEM) Academic Gold Medal 2016 and the JARI Medal (Medal of the Journal of Applied Radiation and Isotopes), 2009, 'In recognition of outstanding contributions to the field of Radiation Physics,' also receiving the accolade of Academic Icon at the University of Malaya, 2012 to 2016. Professor Bradley has been successful in developing a strong grant portfolio.

The IRPS is an organisation to whose furtherance David has been truly dedicated. His involvement in IRPS reaches back to the birth of the Society, participating in the organisation of the

Symposium ISRP-2 in Penang (in 1982) at a time at which the protem committee charged with steering its inception was first set up. The only two other living members of the Society who have had a longer association with the IRPS than himself would be Professors Richard Pratt (University of Pittsburgh) and Suprakash Roy (erstwhile Head of Physics at the Bose Institute, Kolkata), both of whom participated in ISRP-1 (Kolkata). The Proceedings of that meeting appeared as NBS Special Publication 461 (Google 'National Bureau of Standards Special Publication 461, International Symposium on Radiation Physics'). He owns a hardcopy of that Proceedings, and indeed has a hard copy of every single Proceedings.

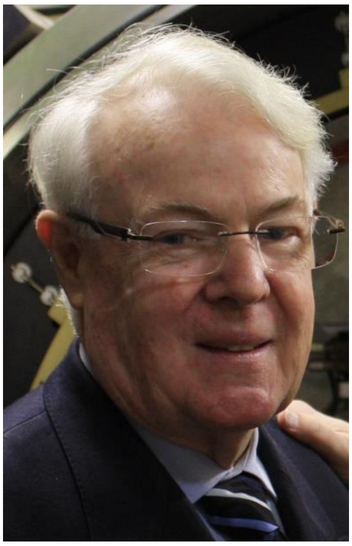
Being too junior to be a member of that committee in 1982 (the names of which included Joseph Rotblat, Daphne Jackson, Didier Isabelle and Ananda Mohan Ghose), he played an important role in behind-the-scenes organisational matters. A.M. Ghose, his PhD supervisor at the time of ISRP-2 (1982 – 1985, with much input from RHP), was together with John Hubbell, one of the two originators of the idea of the Society. IRPS was born on 29 September 1985. In the company of Richard Pratt and John Hubbell, David went on to help write the constitution of the Society, a document that remains largely unscathed, undoubtedly due to the efforts of Richard and John, and to be Assistant Editor with Richard Pratt and subsequently Editor of the very earliest editions of IRPS-NEWS, the forerunner of the present Bulletin, maintaining this means of communication with the membership for close to a decade. In more recent years, he has been an organiser of various of the Symposia and also Editor of several of the Proceedings of ISRP's. A regular attendee of the Council meetings, he has always been proud to have spent time in providing for the needs of the Society. ISRP is a Society of members, providing an important vehicle for many very important aims of scientists involved in a panopoly of radiation physics interests.

He has been involved in so many of the Society activities, early and recently, and perhaps as simple examples one can cite ISRP-15 held in Kuala Lumpur, 6-10 December 2021 (preceded by a Workshop focusing on radiobiology, 5th December), albeit with the great majority of talks presented virtually. A total of 329 participants were attracted to the meeting, coming from more than 44 countries, including from Algeria, Australia, Argentina, Brazil, Bangladesh, China, Croatia, the Czech Republic, Denmark, Egypt, Finland, France, Germany, Indonesia, India, Italy, Iran, Japan, Jamaica, Jordan, Korea, Malaysia, Mexico, Nigeria, Norway, Pakistan, Portugal, Qatar, Romania, Russia, Saudi Arabia, Singapore, Spain, South Africa, Sudan, Taiwan, Thailand, Tanzania, Turkey, the United Arab Emirates, the USA, UK, Vietnam and others. The meeting sessions were contributed to by plenary speakers, keynote lectures, and invited lectures, also with leading experts presenting work in the form of oral and poster presentations, also welcoming contributed papers. A workshop on thematic issues in radiobiology preceded the main event. The high number of representatives from across the globe once again clearly demonstrated the significance of radiation physics and its growing interest to the research community worldwide. One can also mention the 3rd International Forum on Advances in Radiation Physics (IFARP-3), held at Sunway University at its campus located just outside of Kuala Lumpur, helping to engage ASEAN and Oceanic participation. This meeting, conducted entirely online via Zoom on the 24th and 25th February 2021. IFARP-3 was hosted by Sunway University and the University of Melbourne, with Universiti Putra Malaysia as a collaborating body.

I think it is important to discuss a few of David's scientific outcomes. Naturally, lots of publications in Radiation Physics and Chemistry, Applied Radiation and Isotopes or JARI, and The

British Journal of Radiology. Some key cited publications on Biological Agents for synthesising nanoparticles (even the Journal of King Saud University – Science, the highest citations at 350 to date); a book with Dudley on Physical Techniques in the study of art, archaeology and cultural heritage (113 cites to date); papers with Mic Farquharson in Physics in Medicine and Biology on transition metals in breast tissue (280 cites to date); a review of X-ray explosives detection techniques for baggage (334 cites to date); many papers on dosimetry, photoluminescence and silica glass optical fibres and other scintillators; and of course many others. One of my personal favourites is on the Search for Solar Axions using Li-7.

David and I have ‘competed’ in many international conferences in terms of which one of us and our students would either make the best contribution or the most contributions to the event, in terms of talks, posters, and manuscripts. Whilst I might have occasionally had a close victory, the overwhelming success on these metrics has been David and his wonderful students. The Society is perhaps blessed with many members who are able to help one another, and to help the Society, and to help students at talks and posters, and David has been an exceptional contributor to these efforts.



This is a great and appropriate honour for both of these inestimable Members of our Society. Dudley took over the IRPS News from David Bradley and transformed it into the IRPS Bulletin, and has still been active in promoting it and protecting it for the future. I wrote an article in honour of Dudley recently, on the occasion of him being made a member of the order of Australia; and I replicate it here:

My relationship with Emeritus Professor Creagh began as an overseas Australian over 30 years ago, as a young research fellow. He gave up his invited Plenary at a major conference for me, a fellow Australian, to speak on my research. It has always been professional, and we have become peers.

Professor Creagh has always been a statesman for the world and Australia. In the 1970's, he led the development of the Australian National Beamline Facility at the Japanese synchrotron radiation facility, The Photon Factory, situated at Tsukuba. This was the first attempt of Australia of be involved in large facilities in synchrotron and X-ray science. The beamline at the Photon Factory proved to be a productive and successful beamline, and benefitted Australian scientists for over 20 years. Its research output added significantly to the research output for its host Japanese facility. I know the beamline well – after I returned to Australia in the 1990s I became a frequent user of this facility, visiting some 3 times per year for major experiments. After Fukushima I led the team to repair the facility, successfully. I ran the last experiment there before its closure due to Australian funding. I chaired the Closing Ceremony. This success of the beamline led ultimately to the development of the Australian Synchrotron Project, in which again both Prof Creagh and I were significantly involved. Without his guidance it is possible that the projects would not have succeeded. And the next iteration in the development of Australia’s own synchrotron radiation capability, the Australian Synchrotron, might not have occurred.

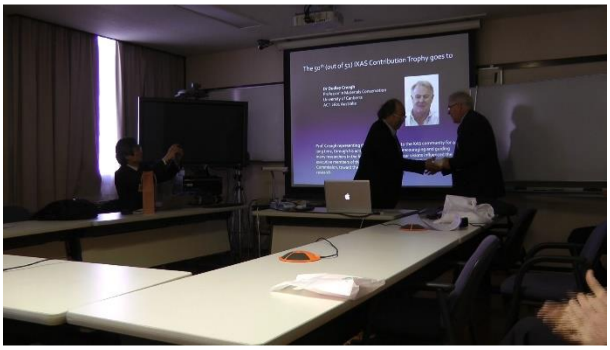
He has always looked out for lost Australians overseas and encouraged them both there and in returning home to careers and futures. He has always reminded the world that Australia is both important and able to make major contributions in Research, and International Policy. His record as Chairman of the Commission for Crystallographic Apparatus of the of the International Radiation Physics Society [IUCr] (11 years), and as President and office bearer of the International Radiation Physics Society [IRPs] (28 years), is exemplary and his is even now providing detailed and expert references, comments and also major contributions to encyclopaediae. I am a Past President of the IRPS and the longest-serving member and Chair of the IUCr Commission on XAFS, and I am in a position to judge the extent to which Prof Creagh's involvement has been influential in the field of X-ray scattering, and how his leadership has led to successful scientific outcomes. We, Australia, have always been able to be neutral and positively encouraging to all other countries and especially to broker agreements and mutual understanding especially where there was strong conflict. Prof Creagh was an exemplar of this, for his whole life, and continuing.

At the University of Canberra, and previously at ADFA, he led interdisciplinary research at a time when those words had little meaning. He made dramatic breakthroughs with Australian indigenous art and Cultural Heritage, at Security Screening for the Defence of our Nation and Borders. He co-designed some of the latest technology now used by Australian customs. Many other countries have taken this up.

Throughout his career he has served as a office bearer in national and international societies: the Australian Institute of Physics (AIP), the Society of Crystallography in Australia (SCA),, the Australian X-ray Analytical Association (AXAA) and the Asian Crystallographic Association (AsCA). This demonstrates the consistent pattern to support and leadership, both of Australian endeavour and of leadership on the world stage. Australian punches far above its weight in X-ray science and Crystallography and synchrotron science [remember the Bragg Nobel prizes are Australian], and he has for a long periods of time led this charge and maintained it. He is personally highly respected around the world, in Japan, in Europe, in the US, and indeed in China. In all these areas, I knew him professionally before I was a peer. And in that respect, I knew his generosity of time and work and spirit as well as his research integrity, before perhaps we became peers.

Emeritus Professor Creagh has recently been honoured for his contributions to science and to tertiary education by being made a member of the Order of Australia (AM).

In the opinion of the many people, he has led and helped and guided, he is worthy of this highest honour. He did not stop giving that advice, guidance and leadership when he retired, he has actively continued to work for good and for science and for Australia and for the IRPS.



With very best wishes, Dudley and David and Congratulations,

Chris

Below is also an extract of the Australian Institute of Physics Lifetime Recognition for Dudley, following his AM:

I was born in Brisbane on 18 February 1935, the second of twins. Our father was a surveyor and our mother returned to her former role as a primary school teacher for the duration of WW2. I expect that the fact that many of my forebears were school teachers led me to incline towards that profession. I was well taught in all of my subjects at the Church of England Grammar School, Brisbane, and in the Senior Public Examination I did equally well in science and arts subjects.

Ultimately my choice to study Physics, Chemistry, and Mathematics was made on the basis that Queensland had a grave shortage of science teachers. I felt that I could become a good teacher of what are now referred to as STEM subjects. As my university studies progressed it became clear that I had an aptitude for Physics and Mathematics. When it came time to decide what direction my post-graduate studies might take, the choice was simple. Physics offered a number of research options, whereas Mathematics, which I had been taking at Honours Level, was offering Number Theory. This is now a “sexy” subject, but then it seemed abstruse and boring. As well, Physics had a professor, Hugh Webster, who was a good leader, and had a quietly persistent “can do” attitude, which I admired.

When he was appointed Professor of Physics in 1949, Webster was faced with the problem of developing new courses with almost no funding. His solution? Buy surplus radar and other second-hand supplies: improvise, innovate, adapt, and develop a good workshop. When I arrived at the University in 1952, I came to a Dickensian Victorian building situated near the Botanic gardens. We were, however, offered courses which were really up-to-date. In practical classes we performed all the experiments of JJ Thompson and, because Webster was the Keeper of Radioisotopes, Rutherford’s a-particle experiments as well. The department moved to its present St Lucia site in 1955. Research was largely focussed on ionospheric physics, but radiation physics related to the human effects of solar and cosmic rays was also offered. There was a general shortage of funds, new research equipment being created by cannibalizing WW2 surplus electronic equipment, and staff and students alike (Webster included) spent time building the Long Pocket ionospheric research site. My task was to develop the elements of a computer to calculate the correlation coefficients between the signals acquired from spaced aerials, each of which could detect the polarization of the received signals. I developed the multiplying, summing, and storage elements for the computer, using reclaimed components. I was awarded a 1st Class Honours degree and continued at university, studying for a Diploma in Education.

What was your first Physics job? What did you like, dislike, and learn from it?

I had been teaching science at Toowoomba High School for a year and a half, and enjoying it, when I received a telephone call from Professor Jack Somerville FRS asking me if I would like to come to the University of New England (UNE) to work with him. I would be a Temporary Lecturer working on a 3-year contract, and he would arrange accommodation for me. I knew a little, but not much, about the Physics Department at UNE. After some deliberation I decided to accept Somerville’s offer and I packed up my possessions and moved south, though with some regrets, I must confess. When I arrived in Armidale, I found that a fire in the Belshaw Block, shared by Chemistry and Physics, had destroyed everything, including the teaching laboratories. My contract included giving lectures in courses decided by the Professor, as well as responsibility for

First Year laboratory classes. The temporary accommodation for the laboratories was not yet completed. What could I do? Remembering how Webster had coped with similar problems, I found out what my working budget was, got to know the workshop staff, and set about deciding what materials were required to re-create the laboratory courses. It was a big task, but we overcame the difficulties. Sometimes I was printing out the laboratory notes on the Gestetner machine only just in time for a class; at other times the laboratory assistant was hurriedly setting out equipment which had only just been assembled.

I had expected that I would continue research in Ionospheric Physics, working on the Luxembourg Effect experiment which was then underway between Sydney University and UQ (Brisbane). This was not to be the case. A book written by Somerville described an experimental technique which had the potential for determining how a spark channel evolved after the current flow in the spark channel had ceased. (The Electric Arc Methuen, London, 1959). The technique relied on the application of a second (probing) pulse to the electrodes after the original spark. This pulse was formed by reflecting the original spark pulse via a terminated transmission line back through the spark gap. But a quick analysis of the existing data showed that this approach was not capable of following the complete evolution of the spark channel. The probing pulse had to come from a separate voltage source. I decided that this could be done if I had a hydrogen thyratron which could be used to apply a probing pulse to the anode at predetermined times, subsequent to the spark. It cost £100 to buy one, a lot of money in those days, but fortunately I received funding from the Radiation Research Board to acquire it. Over the next three years I used this new technique to determine the dynamics of the ionization process. (Creagh et al 1963 Proc Phys Soc 81 480-489) This was my first publication, and in fact, it was the first paper, ever, to describe the full life-cycle of an electric spark. At the end of my tenure at UNE I was faced with a decision about what to do next. I had an offer from Peter Thonemann, who had been charged by the UK Government with the task of establishing a Thermonuclear Fusion Laboratory at Culham, UK, another from Hewlett Packard, and I had applied for a position as lecturer at the Royal Military College (RMC) at Duntroon in Canberra. In the event I chose to accept the RMC offer. The life of a purely “big technology” scientist, although potentially more prestigious, seemed less attractive than that as a teacher. My MSc thesis entitled The Decay of Spark Channels which have Ceased to Carry Current was completed later, and the degree was awarded in 1964. I arrived at RMC to find that the Physics Department had just moved into a new building, having occupied temporary huts since WW2. The staff comprised a professor, two lecturers, a machinist, and a laboratory attendant. The curricula for both science and engineering students were similar to those offered at universities, taught to Third Year level. Selected cadets were sent elsewhere to complete their degree. I could have been disheartened by this. I wasn’t. I could continue doing what I had an aptitude for: teaching. So, I settled in to that task, and I started playing cricket again too. All was in order, so I thought. But at a cricket match one Saturday the Commandant, MAJGEN CH Finlay CBE said to me that he wanted to see me in his office at 0900, Monday. I wondered what I had done wrong. At the meeting he explained that for a decade or more the Department of the Army had been negotiating with the University of New South Wales to make RMC, in effect, a Faculty of UNSW. He said to me, “Give up the cricket, lad…I want you to concentrate on your research, effective immediately”. Good advice…I was not an outstanding cricketer. I had just made tentative arrangements to join Jack Blamey’s group at the RSPhysS at ANU. What should I do? Belonging to a large research group is not consistent with the rapid production of research publications. However, I read in the paper that the Snowy Mountains Authority was closing down its spectroscopy facility and were offering the complete package with its Hilger high-resolution spectrometer and all accessories to anyone who would take it away (it literally weighed a ton). I asked the relevant RMC staff officer about what could be done and, bingo, a 3-ton truck with a Section of troops went to fetch it. And it was duly installed in the darkroom. My scheme was to adapt the spectrometer to enable the measurement of the radial temperature distribution in low-current DC arcs. It required some magic with mirrors to place an undistorted image of the arc on the entrance slit of the spectrometer, plus the invention of a current stabilization system capable of handling 10 Amps. Publications followed in 1965 and 1968.

From 1962 to 1968, courses at RMC evolved. RMC as an institution made the transition to being a College of the University of New South Wales. This was an era of rapid change, in curriculum, staff, and equipment acquisition. The field of Solid State Physics (Materials Science) was seen as an essential element of the new Physics curriculum and to teach it, new equipment was acquired and brought into operation. The new equipment included transmission and scanning electron microscopes, an X-ray diffractometer, and an X-ray fluorescence spectrometer. I decided that I needed to acquire some formal education in Solid State Physics to be able to teach the new courses effectively. It must be remembered that at this time the transistor was a novel device, and the mysteries of semiconductor physics had yet to be revealed. I applied for and was granted a Commonwealth Post-Graduate Scholarship to undertake the MSc course in the Physics of Materials at the University of Bristol. The research element of this degree involved the use of Michael Hart's newly invented X-ray interferometer for the measurement of X-ray refractive indices. I was awarded an MSc for a thesis entitled: The measurement of X-ray refractive indices using an X-ray interferometer. This led to further research in the field of X-ray scattering. X-ray interferometer studies enabled me to make precise measurements of the X-ray anomalous dispersion corrections of atoms. My experiments showed a discrepancy with the current theoretical predictions which were based on non-relativistic models of photon scattering. I used a relativistic quantum mechanical multipole model of photon scattering and found that the predictions from this model were in close agreement with the experimental data. On my return to RMC, I continued research into the measurement of the temperature distribution in electric arcs. As well, I pursued work on X-ray scattering, devising equipment which could measure X-ray absorption to a greater precision than had hitherto been attained. The scattering and absorption processes are causally linked, so the results of an interferometry experiment could be used to predict the anomalous dispersion corrections and vice versa.

1971 Professor Geoff Wilson became Professor of Physics at RMC in 1971. Wilson was given funds to establish research in his field of Condensed Matter Physics, in particular, studies of magnetic materials such as the cobalt, samarium, holmium, and the cubic Laves phase intermetallic metals. In the Wilson made it clear to me that I needed to have a PhD to expect advancement within the University. I agreed to enrol for the degree, but I would be studying X-ray Scattering, not magnetic materials. However, I said, I would help him if he needed it. I promptly enrolled for a PhD and in 1975 was awarded the degree for a thesis entitled Measurement of X-ray dispersion corrections and mass absorption coefficients for various halides. Keeping my promise to Wilson, in the years from 1970 to 1982 I was involved in the study of the structure and properties of the materials of interest to his group, using a variety of techniques: X-ray diffraction, nuclear magnetic resonance (NMR), ferromagnetic resonance (FMR), and the Mössbauer technique. I was then author or co-author of 7 publications.

I took very brief sabbatical leave in 1977 at the (then) US National Bureau of Standards (NBS) working with John Hubbell. My task was to study the results of experiments carried on at Stanford, a newly established synchrotron radiation facility in the field of Extended X-ray Absorption Fine Structure (EXAFS). Hubbell had reservations about the reliability of data being produced. I examined about 1000 reports and papers, and found that only about 100 were free of compromising artefacts. For me, this was the start of a long-continuing investigation, both theoretical and experimental, into X-ray absorption near the absorption edges in materials. The NBS awarded me their Citation for Excellence for research completed there.

In 1978 I received an invitation from the International Union of Crystallography (IUCr) to set up an international round-robin experiment for the measurement of X-ray attenuation coefficients. Eleven international laboratories, in the US, Europe, and Australia, participated in the experiment. These laboratories were provided with sets of well-characterized specimens prepared by the physics workshop at RMC. I then replicated the experimental arrangements used by the participating laboratories in my RMC laboratory. The results of this study led to improvements in the quality of data collection of X-ray absorption data, worldwide.

In 1979 I was awarded a French Government Scientific and Technical Fellowship. I worked with Professor Erwin Bertaut at the Institute Laue Langevin (ILL), Grenoble, on group theoretical studies of magnetic spin ordering in solids, and with Professor Andre Authier (University of Paris V: Pierre and Marie Curie) on the possibility of observing nuclear anomalous scattering in cadmium sulphide using neutron scattering.

The 1980s saw the establishment of the Australian Defence Force Academy (ADFA), an amalgamation of the existing service colleges (Army: RMC; Air Force: Point Cook; Navy: Jervis Bay). With this came new courses and the need to design experimental suites for the new Physics Building. It was a very busy time as I was responsible for the planning, management and maintenance of these facilities. Throughout my career at RMC and ADFA (1962-1996), I carried a full teaching load, teaching mostly 2nd and 3rd year students conceptually difficult subjects, like quantum mechanics. All of my Honours students earned 1st Class Honours…one with a University Medal. I left ADFA in July, 1996, and took up an offer from the Vice-Chancellor of the University of Canberra, Professor Don Aitkin, to act as a mentor to staff and postgraduate students and to give him advice on technical matters. I remained at the University of Canberra, now as Emeritus Professor. In November 2024, I gave a paper at the 50th National Meeting of the Australian Institute for the Conservation of Cultural Heritage (AICCM) on Studies of Cultural Heritage Artefacts using X-rays, a review of 40 years of research in this field. Until 1980, my research activities lay in studies of X-ray scattering and the structure of materials.

In 1980, the IUCr invited me to be Chairman of its Commission on Crystallographic Apparatus, a position I held until 1993. My focus changed somewhat to issues pertaining to crystallography in general, and the X-ray scattering parameters used in the analysis of the data from X-ray diffraction experiments. My other research interests remained, of course, and in what follows I shall outline highlights of my activities in these fields sequentially, although the events happened in parallel, and sometimes spilled over from one to another.

X-ray Scattering

In 1988, the IUCr invited me to contribute chapters on X-ray scattering to their handbook, International Tables for Crystallography Volume C (ITC). This serves as a source of reference data for more than 100,000 researchers worldwide. I wrote five Sections in Chapter 4 of this volume: on X-ray spectra, X-ray attenuation, X-ray dispersion corrections, monochromators, and Chapter 8 on precautions against radiation injury.

At the 1981 IUCr Congress in Montreal, I encountered an old Chinese gentleman who was having problems making a vending machine work. I helped him. It transpired that he had studied in Cambridge before WW2, he was head of a delegation from Academia Sinica, and had been with Mao on his long March. Interesting…but I thought no more about it. You try to help people when they have problems. Then, out of the blue, in 1989 the Academia Sinica invited me to give lecture courses in Beijing on modern X-ray scattering theory and practice. The research conditions prevailing in China at that time were primitive to say the least. They were keen to learn, and I was pleased to be able to help them. They asked me whether they could copy my Overhead Projector foils. I said yes, and they duly copied them - by hand! They did not have a photocopier. When I had finished the course, the President of the Academia Sinica presented me with the Chinese Chemical Society Medal in recognition of my service to the Chinese Academy of Science.

In 2012, I received an award from the International X-ray Absorption Society for my work on X-ray Scattering. Revisions of ITC have occurred at roughly four-year intervals since its first publication. A total revision was deemed necessary by the IUCr Publications Commission in 2017. The revision of the entire Chapter 4, which inter alia contains the tables of scattering parameters, has been undertaken in collaboration with Professor Chris Chantler, and is now in the hands of the publisher. The practical uses of X-ray scattering are many.

One of these is related to security matters at Australia’s border. In 1999 the Australian Customs Service (ACS) asked me to assist them in a project aimed at installing shipping container x-ray search facilities (~6 MeV X-ray systems) at Australian ports. This project involved the evaluation of the performance of suitable equipment. A pallet-mounted test piece was designed to enable the testing of vendors’ products in overseas locations. Later projects involved the design of test objects for the performance testing of all the systems (X-rays, THz, mm Wave, IR, etc) a passenger would encounter at an airline portal. I ceased working on Australian Government projects in 2015, with the creation of Border Force. But I have continued in my work on the development of standards for all types of security systems as a member of Working Group 47 of the Comité Internationale Electrotechnique (IEC).

In 1984, at the Hamburg IUCr Congress, Junichi Chikawa, the Director of the Photon Factory (PF), the new Japanese synchrotron in Tsukuba, invited Stephen Wilkins (CSIRO Materials Division) and me to establish an Australian beamline at the PF. The Japanese would reserve a beam port for Australian scientists, he said. We came back to Australia and proceeded to try to raise both interest and funding. At this time, you could count the number of Australian synchrotron users on the fingers of one hand. What ensued was five years of meetings with Government agencies, the AAS, ASTEC, the CSIRO, workshops, reports…a hard slog. Two ARC submissions were rejected, for nonsensical reasons. Finally, the AAS produced a report based on a survey by Hans Freeman and John White “Small Country Big Science”, which recommended to Government in 1989 that the government should fund the project to the tune of $2.7M over 3 years. The Minister responsible, Simon Crean, told us “It is in the budget”.

But it wasn’t. Eventually the then Chairman of the ARC, Professor Don Aitkin, intervened and set up a consortium, comprising Ansto, CSIRO Materials Division, a representative of DIST, the RSC-ANU, and ADFA, which was to receive $3.3M over 3 years. The AAS had a representative, Hans Freeman, but he did not have voting rights: the AAS was not putting money into the project. Not one Australian university contributed funds the project, which I found exceptionally disappointing and short-sighted: they stood to gain most if the project succeeded.

The first meeting of the Consortium to run the Australian National Beamline Facility (ANBF) was held in 1990. The beamline was to be situated at take-off port BL20B of the PF. Building a synchrotron radiation beamline in 3 years is no small task and the funding provided was ridiculously low. I had to design the beamline complete with monochromator and the experimental hutch, as well as providing the ‘container house’ in which staff and visitors would work. Stephen Wilkins and I were to design the high-resolution vacuum X-ray diffractometer (BIGDIFF), and the work station behind BIGDIFF on which the XAFS equipment would be mounted. I was Chairman of the Technical Committee, John White (RSC-ANU) was Chairman of the Program and Review Committee, and David Cook (Ansto) managed the budget, personnel, computing, and other administrative matters.

It was immediately apparent that we could not afford to buy both commercially-made slit systems and the monochromator. It was a definitely a DIY project. Fortunately, ADFA Physics had an excellent workshop and equally good staff. They built the beamline, the monochromator, and all the mechanical and electrical systems. The diffractometer, which was always going to be a DIY project because it was unique, was built in the CSIRO Materials Division workshops. Fortunately, we were able to achieve all of these things remarkably quickly. By 1992, we were already conducting white-beam experiments such as Laue Backscatter experiments on single crystal rare earth specimens and Energy Dispersive XRD on MgSiO3.

And when the monochromator was installed, we were able to perform XAFS experiments. We were in full operation when the diffractometer arrived in late 1993. We performed proof of concept experiments such as tensometry of polyurethanes, Small Angle X-ray Scattering (SAXS), and X-ray Reflectivity (XRR) studies of protective coatings on metals using ad hoc devices made from components which were on hand. By the time our funding had run out in 1996, we had delivered what we had set out to do: produce a world-class, versatile, vacuum X-ray diffractometer and a highly competitive XAFS system. The user community had grown to more than 200. Clearly, we had done what we had said we would do - and more - within the constraints of a very tight budget.

Chantler group at decommissioning of BIGDIFF Participants in the last experiment at BL20B. Le to right: Noel Excell, Lachlan Tantau, Feng Wan Stephen Best, Dudley Creagh, Chris Chantler (Team Leader), Tauhid Islam, Kathrine Spiers (Beamline Scientist), Alexis Illig.

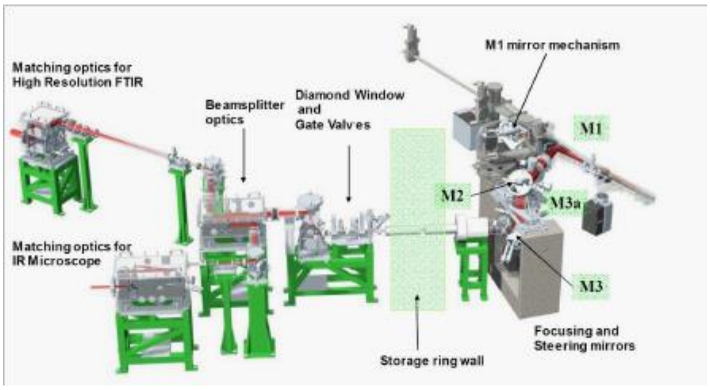
At the flag draping ceremony. Left to right: Masami Ando, Hiroshi Kawata, Jimpei Harada, Dudley Creagh, Chris Chantler, Kathrine Spiers

There was a period of panic in 1996, when we thought we would lose funding, with the inevitable result of shutting down the project. But the Government had set up a new class of research grants, the Major National Facilities Program, and a new Australian synchrotron initiative, the Australian Synchrotron Research Program (ASRP) was created. This program was allocated a grant of $15M over 10 years. The PF facility was part of the ASRP structure, receiving additional funding for ancillary equipment, and I remained as its Director. The program also gained access to beamlines at the CARS facility at the Argonne National Laboratory in the US.

The decision to create the Australian Synchrotron in 2001 drove another change in my research direction, becoming a member of the National Synchrotron Advisory Committee. There were to be nine beamlines, each using different characteristics of the synchrotron radiation spectrum and different types of experiment, viz: high-throughput protein diffraction, high resolution XRD, SAXS/WAXS, XAS/XAFS, X-ray Imaging and Therapy, Lithography, Soft X-ray Spectroscopy, Micro-spectroscopy, and IR & Vibrational Spectroscopy. Interest groups had formed for eight of the beamlines during the first years of the ASRP.

No one was prepared to take responsibility for the IR beamline, so I said I would do it. People said openly that I couldn't do this, that I didn't have the background. They were not aware that I had a

Raman microscope and IR systems in my UC laboratory because of my involvement in cultural heritage research. Nor did they know of my research on electric arcs, which required expertise in optics. I had a budget of $2.2M. The real problem was how to extract the IR beam from the vacuum in which the charged particles circulate. As well, the beam path had to be as short as possible, there had to be 1:1 magnification, the effects of vibration from the floor had to be minimised, and beam instability effects minimized. Suffice to say that the design team (Jonathon McKinlay, Paul Dumas, and myself) overcame all the difficulties, which included redesigning the vacuum vessel so that we could take the beam out horizontally. We were actually doing experiments at the time the Australian Synchrotron was officially opened - the only beamline to be fully operational. Not only that. The extracted beam has two components: one coming from the bending magnet and the other from the location where the charged particle enters the fringing field of the magnet (so-called edge radiation). These could be separated by the downstream optics and pass, in this case, to an IR spectrometer and a high-resolution THz spectrometer. Two beamlines for the price of one. And $200K under budget.



The IR/THz beamline is regarded as one of the best in the world. Take-off chambers similar to the one we designed have been installed at two other points on the ring, to be used should demand for beamtime exceed the present available level. My formal involvement in the management of AS projects and the ASPF Photon Factory presence ceased with the opening of the beamline in 2008. I did, however, keep improving the XAS detector systems at the Photon Factory through successive ARC grants. In 2018 at its annual Users' Group Meeting, I received inaugural award of the Medal for Lifetime Contribution to Synchrotron Radiation Science.

Cultural Heritage Studies

The Australian Institute for the Conservation of Cultural Materials (AICCM) is 50 years old this year. When it was formed there were perhaps fifteen people who identified themselves as conservators in Australia. The lack of proper care for the collections in museums and galleries was a national disgrace. Public outcry about this, and pressure from historians on the Whitlam government in 1974, led to setting up the Pigott inquiry which found, in 1975, that conservators should be tertiary-trained, and that the (then) Canberra College for Advanced Education should deliver the course. The CCAE was just 7 years' old. The president of the AICCM, Colin Pearson, was appointed as Senior Lecturer and courses began in 1976.

The Australian War Memorial (AWM) had been singled out for criticism in particular, perhaps because it is a national icon. Whitlam decreed that there would be a purpose-built facility for the AWM to be the 'best conservation facility in the world'. Enrico Taglietti was engaged as the architect with building commencing in 1975. The building was completed in 1979, opening in time to receive the first graduands of the CCAE course. Although the facility was undeniably first rate, as a conservation laboratory it lacked the sophisticated analytical equipment necessary to characterize the objects being treated. One of the conservators, David Hallam, happened to be complaining about the cost of having samples tested in external laboratories to my wife, Helen, an archivist then working at the AWM. She said, “Dudley can do that”. I met with David, and that, as they say in the song, was the start of something big. This is the 40th anniversary of my collaboration with conservators from the AWM, other Australian collecting institutions, and internationally.

I list below some important projects and unless otherwise stated the techniques employed in the analyses were those in my laboratory at RMC/ADFA and UC:

In the 1980s: I undertook the characterization of all materials in the panels and spars in a Japanese zero salvaged post war in PNG and being reconstructed by apprentices at the RAAF Apprentices School; studied the metallurgy of the Lusitania medals; and conducted a detailed study of all the Victoria Crosses held by the AWM and NZ museums. This data is used to validate the authenticity of the medals.

In the 1990s: We studied the Carley Float, the sole relic of the disastrous encounter of the HMAS Sydney and the HSK Kormoran in the Indian Ocean in 1942. We gave evidence at enquiries into the sinking 1993 and 2010. Using Electrochemical Impedance Spectroscopy we tested the efficacy of materials used to coat outdoor statues. Using X-ray reflectivity at the ANBF, showed how lubrication oils work.

In the 2000s: I edited a book (with David Bradley) Radiation in Art and Archaeometry. (Elsevier Science BV. Amsterdam. (ISBN: 0 444 50487 7). This was one of the first books published on the application of science to art and archaeometry. Two more books were to follow (in 2006 and 2007). My group made a detailed study of the making of traditional Aboriginal bark paintings, and we analysed ochres and white pigments used by Arnhem Land clan groups. This was undertaken so we could give advice on how to improve the long-term stability of the paintings displayed in museums and galleries. We made use of Raman microscopy and the IR Beamline at the Australian Synchrotron to study the effects of aging on iron gall inks on parchment. Metallurgical examinations were conducted at Ansto on bushranger armour: Ned Kelly’s helmet, to study the dents caused by the impact of the rifle bullets, and Joe Byrne’s armour to establish the method of fabrication.

In the 2010s: We used the X-ray Fluorescence Microscope (XFM) at the Australian Synchrotron (AS) to uncover paintings which have been overpainted. Also using the XFM facility, in collaboration with the Rijksmusuem, we examined the Dutch National Treasure, the Dirk Hartogh plate, with a view to producing a strategy for its long-term preservation.

Using the THz facility at the AS, David Thurrogood and I characterised pigments from the palette and studio of van Gogh, and as well from the studio of Arthur Streeton. At the Anso Opal facility we used neutron tomography, neutron diffraction, and neutron stress analysis to make a complete metallurgical study of WW2 Japanese swords in the collection of the Queen Victoria Museum and Gallery in Tasmania. This was a collaboration with (the late) David Thurrowgood, and Filomena Salvemini (ANSTO), The casual conversation between David Hallam and my wife in 1980 was the catalyst for significant developments to occur in the field of Cultural Heritage Conservation in Australia.

The recent AICCM 50th national conference was attended by 220 conservators (the lecture theatre was full), with as many more watching the event by video link. What started as a natural extension of my work on the Physics of Materials has become an endless source of interest and enjoyment to me.

The International Radiation Physics Society awarded me a Lifetime Achievement Award in 2015 for my work on all aspects of the interaction of radiation with materials, and my service to the Society on its Council and as its President.

On Australia Day 2024 I was made a Member of the Australian Order (AM). The citation is: for significant service to science, and to tertiary education.

Awards

- Commonwealth of Australia: Award of Member of the Order of Australia (AM) 2024.
- ANSTO: Inaugural Award of the Medal for Lifetime Contributions to Synchrotron Radiation Science 2018
- International Radiation Physics Society: Lifetime Achievement Award. 2015
- International X-ray Absorption Society: Lifetime Achievement Award 2012
- (Japanese Government) Monbusho: Technical Fellowship 1993
- Chinese Chemical Society: recognition of service to the Chinese Academy of Science: 1989 United States National Bureau of Standards: Citation for Excellence 1987
- French Government Scientific and Technical Fellowship 1979
- Commonwealth Postgraduate Award: 1965

Advice to a new physics graduate?

- Accept what life offers, adopt those elements you can live with, adapt those you cannot to be in a form more acceptable to you.
- Believe in yourself, have confidence in your abilities: act more with humility than hubris in discussions with others.
- Collaborate as widely as is possible.
- Skills: The development of your skill set in your primary field of interest and the acquisition of skills in other, parallel fields, is essential.