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Historical Records of Australian Science

Guy Kendall White 1925–2018

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ABSTRACT

Guy Kendall White graduated from the University of Sydney, obtaining a BSc (Hons) (1st class) in 1945 and an MSc in 1947. He attended the University of Oxford and obtained a DPhil, studying low-temperature physics in the Clarendon Laboratory. He had a productive research career as a condensed matter experimental physicist, focusing on transport and thermophysical properties of solids at low temperatures. He had an extensive network of international collaborators and, in 1959, authored *Experimental Techniques in Low-Temperature Physics*, which came to be regarded as an essential handbook for those doing low-temperature physics. He was a world leader in the field of thermal expansion in solids at low temperatures. He produced important compilations of thermophysical data that are of great value to technologists, scientists and engineers. He was influential in the development of the discipline of solid state physics in Australia, and his mentoring launched the careers of many young scientists.

Keywords: Australian condensed matter physics, Guy White, low-temperature thermal expansion.

Introduction[1]

Guy Kendall White (Fig. 1) died on 22 May 2018, just nine days short of his 93rd birthday, after a productive life as a condensed matter experimental physicist. He was educated in Sydney at Scots College and then the University of Sydney. Whilst at university in the mid-1940s he secured a vacation job at the recently opened Council of Scientific and Industrial Research (CSIR) National Standards Laboratory. It was this good fortune that afforded him the opportunity to obtain a DPhil from the University of Oxford, supported by a CSIR Overseas Studentship. From his time as a student at Oxford to retirement, his research focus remained the transport and thermal properties of solids at low temperatures, somewhat unusual when compared with the current generation of scientists who often experience changes in their research field during their careers. For almost all of his research career he worked for the CSIRO (CSIR was renamed CSIRO in 1949), though over the years, internal CSIRO reorganisations resulted in the National Standards Laboratory (NSL) being renamed the National Measurement Laboratory (NML) in 1974, and in 1977–8 it relocated to the Sydney suburb of Lindfield, becoming the CSIRO Division of Applied Physics. White's time at Oxford awakened him to the value of international collaborations and these played a major part in his subsequent scientific career. White made major contributions to the development of solid state physics (now perhaps better known as condensed matter physics/materials science) in Australia. He retained his love of the bush, a legacy of his early childhood, as well as a love of sport, notably watching cricket and rugby union, playing tennis, golf, doing body surfing and swimming at which he excelled personally, in his youth.

[1]Much information in this biographical memoir is sourced from the interview of Guy White by Neville Fletcher for the Australian Academy of Science in 2010 (https://www.science.org.au/learning/general-audience/history/interviews-australian-scientists/dr-guy-white-1925-2018-physicist).

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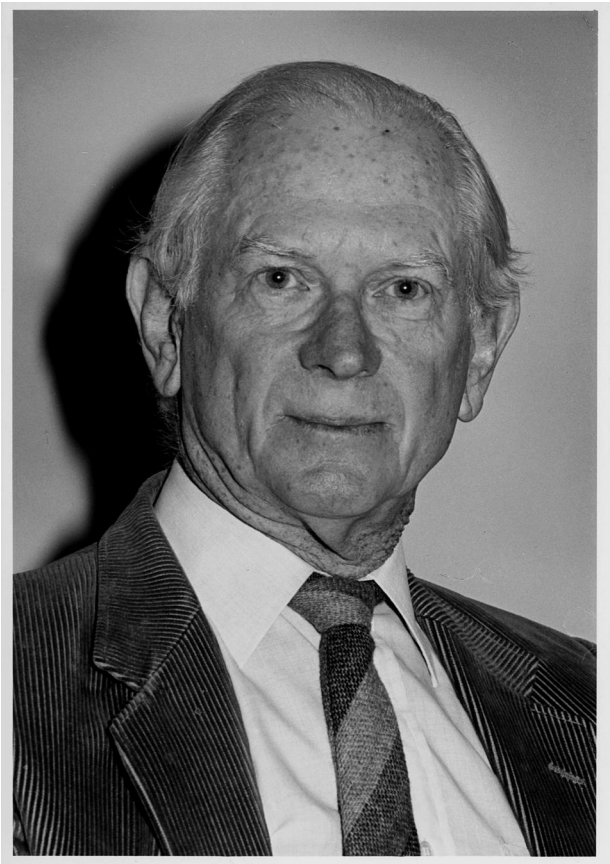

Fig. 1. Guy Kendall White—1993 (photo courtesy of the Australian Academy of Science).

The beginning (1925–35)

White was an only child and he was a country boy. His father, Perceval White (known as Percy), had experienced the horrors of the First World War in a light horse regiment at Gallipoli and the Sinai, and was forty-six by the time he returned to Australia. He married Eugénie Kendall in 1924 and Guy Kendall White was born in 1925. White's early years were spent in the Central Coast and Hunter regions of New Sout Wales. His father had an orange orchard at Terrigal, but the orchard business failed in 1930, at the beginning of the Great Depression. These were tough times, and his father then got a job with his brother on a property called Albilbah, near Blackall, Queensland, where he stayed for the rest of his life. This remote property had no married quarters and no school, so White lived with his mother who, initially, took jobs looking after houses of old friends in the Dungog area and then in Goondiwindi where, at the age of about six, White learned to ride. Within a few years he became a fair horseman. His friends and relations were always glad to have him visit to assist with the herding of cattle and sheep. His holidays were often spent in the Hunter Valley area where many of the pastoralist White families were based. Indeed, in many ways, White was always a country boy, having a great affinity for the bush throughout his life. He loved the remoteness and had an excellent knowledge of Australian native flora and fauna. Even in his later years he continued to venture far and wide on outback tours.

At the age of ten, White moved to Sydney with his mother, where they rented an inexpensive flat in Rose Bay. Initially with the assistance of friends and relations and later, a scholarship, he attended Scots College, as a day boy.

School years and university (1935–47)

At Scots College, White was strongly influenced by a particular science teacher, Michael Simmons, who had a PhD from the University of London. So it was through experiments in physics and chemistry, under the guidance of Simmons, that his future career as a scientist had its beginnings. He graduated as Dux of Scots College in 1941 and also as its swimming champion (Fig. 2). White returned to Scots College for a time in 1942, at the invitation of the headmaster, whilst waiting to see if he would be awarded a bursary to attend university.

At Scots College, White was also influenced by a very good geology teacher and when he gained entry to the University of Sydney, his intention was to study geology. He ended up studying geology for a year but did not continue with it as he was of the view that there were limited job opportunities. In his first year at university he studied organic chemistry, which he found a bit dull, and physics, that 'gradually grabbed his curiosity'. He developed a strong interest in physics, stimulated by a vacation physics job he obtained at the CSIR's NSL, where, in 1940, staff had begun work in a newly completed building located within the grounds of the university.[2] This was wartime, and White found himself working alongside talented and motivated people in areas such as heat, measuring and controlling temperatures, and photometry. The photometry was measuring the characteristics of filters that were used by aircraft pilots who needed to have particular types of filters for plane spotting.

White completed his studies at the University of Sydney, obtaining a BSc (Hons) (1st class) (1942 − 5) and an MSc (1946 − 7) in nuclear physics for which he used a plasma source to produce deuterons fired at other deuterons to produce neutrons. He confessed that he was 'not grabbed by nuclear physics' but it was fun and taught him much about high-vacuum techniques.

Oxford (1947–50)

White was keen to pursue postgraduate study and knew that he was assured of a CSIR Overseas Studentship. It was

[2]Rivett (1941).


WELL LADEN WITH CUPS

GUY WHITE, a junior, won Scots College senior championship swimming at North Sydney yesterday. Here he is with his trophies.

Fig. 2. The young Guy White, swimming champion (clipping from the *Daily Telegraph*, 25 March 1941, p. 18, courtesy of Guy White's family).

suggested to him by George Briggs, Chief of the Division of Physics, NSL, 1945–58, that Australia had a knowledge deficiency in cryogenics and low-temperature physics, and that this would be a good area for him to study. White accepted a CSIR Overseas Studentship and departed for the Clarendon Laboratory, Oxford, to pursue his physics studies.

In this period after the Second World War, the Clarendon Laboratory was the key low-temperature laboratory in the United Kingdom. It had benefited from the arrival some years earlier of three excellent scientists of Jewish backgrounds, who had wisely decided to leave Germany, Franz Simon, Kurt Mendelssohn and Nicholas Kurti. Simon, later Sir Francis Simon, was White's supervisor, and he suggested to White that he study the properties of solids, in particular electrical and thermal conductivity, from liquid-helium temperatures to ~100 K. But before proceeding with this, Simon requested White build an improved helium liquefier. So, White's DPhil focused on measuring the rate at which superfluid helium flowed through very fine channels, and the

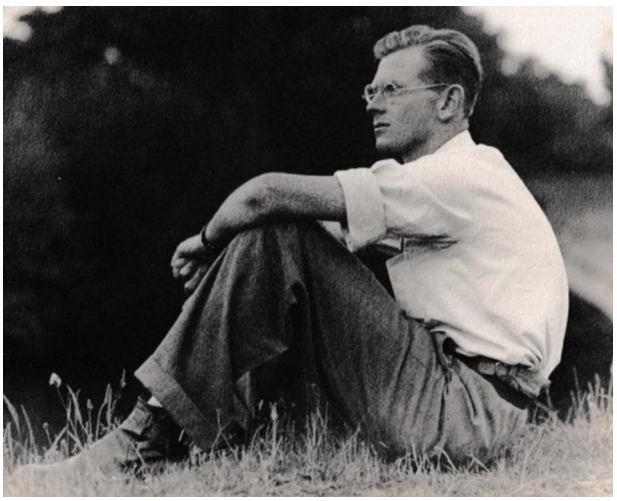

Fig. 3. A young and contemplative Guy White enjoying the parks of Oxford in 1950, photographed by his friend, A. J. Croft (photo courtesy of Guy White's family).

construction of a helium liquefier, as is evident from his early publications listed in the Supplementary Material.

White's time at Oxford was rewarding. Whilst at the Clarendon, he became a member of Magdalen College and for a while captained the Oxford Swimming Club, being awarded a 'Blue' in swimming after being a member of the 1949 Oxford Swimming Team, which defeated Cambridge, convincingly, forty-two to eleven. White was an Oxford man (Fig. 3), and he made deep and life-long friendships whilst he was at Oxford. Throughout his research career, White regularly seemed to have research collaborations with one or more colleagues at the Clarendon, and he returned frequently to catch-up with people at Oxford, and also to taste the 'Oxford air'.

Before White left Oxford to return to Australia in 1950, Sir Francis Simon advised, 'White, I would not try to do work on the properties of liquid helium or superconductivity. You are too far away. The main work on that is here, and in Leiden, Harvard, MIT and Cambridge. But there is all this other work on the transport properties, that is the thermal properties, of materials over the whole temperature range that we don't know very much about.' For those of us familiar with White's research, we can see the echo of Sir Francis Simon's remarks in his future career.

Return to Sydney (1950–3)

Having been in Oxford on a CSIR studentship, White was assured of a position back at NSL in Sydney, to which he returned in 1950 (Fig. 4). There he worked closely with Paul Klemens, a theorist, who had also received a studentship to Oxford. Also at this time, largely due to the hard work of W. R. G. Kemp, a helium liquefier had been constructed at NSL.

Fig. 4. Experimentalist Guy White at work in his early years at the National Standards Laboratory (photo courtesy of Guy White's family).

White and Klemens formed a successful team, measuring primarily low-temperature thermal and electrical conductivities of various metals, notably copper, silver, gold, magnesium and aluminium, in their various states of purity relevant to industrial applications.

They were also joined by another Australian, John Rayne who had returned from a CSIR studentship spent at the Chicago Institute of Metals where he had done research on the temperature dependence of elastic constants, as determined by sound-velocity measurements, and the heat capacity of solids. These research areas complemented, and fitted nicely, with the on-going thermal and electrical conductivity studies, and the research activities of the group expanded accordingly. Such research was particularly relevant at the time, considering the developing 'international space race' in which materials would be required to function at cryogenic temperatures.

Canada and the textbook on experimental low-temperature physics (1953–8)

After three years back at NSL, as White admitted much later, he had developed 'itchy feet and wanted to travel.' A chance meeting with Dr Leslie Howlett, of the National Research Council (NRC) of Canada, Ottawa, during an ANZAS Conference, led to an appointment as an NRC research associate. White spent a total of four years at the NRC, 1953–8, returning briefly to Sydney and the NSL in 1955 when he married Judith McAuliffe. Judith had been brought up in a pastoralist family in rural New South Wales, and throughout their married and family life of almost forty years, she shared White's interests in the outdoors as well as being very supportive of his research career. Together, they returned to Canada where their first two children, Eugénie and Guy junior, were born. His major research during this period, as can be judged from the published papers listed in the Supplementary Material, focused on the thermal and electrical conductivities of various metals and alloys, conducted in collaboration with S. B. Woods. For one particular study on the conductivities of the alkali metals,[3] he reconnected with Keith MacDonald, a colleague from his days in the Clarendon Laboratory in Oxford.

It was during this period that his most significant book, entitled *Experimental Techniques in Low-Temperature Physics*, was published,[4] which has been translated into several languages including Russian and Chinese.[5] White published two subsequent updated editions of this book in 1968,[6] and 1979,[7] and the fourth edition, in collaboration with Philip J. Meeson (H. H. Wills Laboratory, University of Bristol), in 2002.[8]

The first edition of White's textbook quickly became the handbook of those doing low-temperature experimental physics. It fulfilled a need resulting from the increase in the number of people (both students and researchers) around the world engaged in the expanding discipline of low-temperature physics, driven by the improved availability of liquid helium. It is correct to say that no similar textbook was available at the time and White's text contained sections on general aspects of low temperatures, the construction and operation of a research cryostat and a summary of physical data at low temperatures. By the time of the second edition, which extended to 397 pages, the use of liquid ^{3}He as a coolant had occurred and superconducting magnets had become widely used for low-temperature research requiring a high magnetic field. The preparatory work for the second edition was done while

[3] MacDonald and others (1956).
[4] White (1959).
[5] Details of the publication of these translations of White's book have not been located in sources such as WorldCat and specialist journals.
[6] White (1968).
[7] White (1979).
[8] White and Meeson (2002).

White was spending time at the Bell Telephone Laboratories in New Jersey. The third edition, surprisingly, was shorter than the second at 331 pages, but contained updates particularly on applications of superconductivity and the requirements for cooling to even lower temperatures (typically in the milliKelvin range) using both liquid ^{3}He systems and dilution refrigeration, a technology that relies on the phase separation of liquid ^{3}He/^{4}He mixtures below about 870 mK. Cooling occurs, as there is a net absorption of energy, when the lighter upper ^{3}He atoms 'evaporate' across the phase boundary downwards into the denser ^{4}He phase.[9]

The fourth edition (further reduced to 280 pages) took into account the major changes in cryogenic technology since the publication date of the third edition. These changes included areas of temperature measurement and control, the development of new magnetic field and temperature sensors, superconducting magnets, closed-circuit cryocoolers, ultra-low temperatures including dilution refrigeration, technical data on materials, and commercially available cryostats for optical, X-ray, thermal and electrical measurements. There was less emphasis on methods of constructing cryostats in the laboratory and more emphasis on commercially available cryostat systems given that the computer-control of apparatus for low-temperature property measurement had become fashionable and readily available from commercial equipment suppliers. New appendices were added, one providing the details of suppliers of all equipment relevant to undertaking low-temperature physics research, and a second containing comprehensive, up-to-date tables of physical property data on metals, polymers and ceramics.

The changes in subject matter from the first to the fourth edition of White's book, a time span of forty-three years, provide a record of the development, and maturing, of the field of low-temperature physics. Also, they chart White's research career, the first edition being written when he was a young man, in a relatively immature field, and an era of glass cryostats, usually locally made, and notebooks for the manual recording of measurements. Move forward to 2002, White was retired, low-temperature experiments had been transformed by the availability of computer-controlled equipment from commercial suppliers, and he was internationally recognised as influencing and making immense contributions to the now mature field of low-temperature physics. His research career mirrored the development of low-temperature experimental physics.

White was to some extent surprised by the impact of his book, and his influence, on the development of low-temperature experimental physics globally. On a visit to China, in the late 1980s, he was humbled and embarrassed by the attention he received from his Chinese hosts, as he was seen as the 'father of low-temperature physics' in China.

Return to CSIRO in 1958 and beyond

Despite a productive period of research for White in Canada, the cold, a love of the Australian outdoors, and the desire to settle down with his family, prompted a return to Sydney in 1958. The family's third child, Katrina, was born in 1960. For White, having spent some years measuring mainly the electrical and thermal conductivities of solids, and despite the ongoing fascination in these properties created by the unusual effects of impurities or magnetic transitions, it became clear that it was time for a change of research direction. He identified there was a gap—a need for highly accurate measurement of the thermal expansion of solids at low temperatures.

The measurement of thermal expansion of solids at low temperatures is challenging. For example, at 5 K a copper specimen of ~100 mm length will expand ~0.5 nm over a 1 K interval, requiring the measurement of a length change of ~0.005 nm to achieve an accuracy of 1%.[10] On White's return to the NSL in 1958, he began to ponder how he might measure such small changes in length. He had already exchanged ideas with Clay Swenson at Ames Laboratory in Iowa, USA, who was trying an inductance method and Niels Olsen, E.T.H. Laboratory in Zurich, who was using an optical lever device. Both these techniques appeared to have some fundamental difficulties.

White became aware of work being done in another part of NSL on precise measurements of capacitance by Mel Thompson,[11] and by Thompson and Doug Lampard, in developing very sensitive ratio transformer bridges capable of comparing capacitances with a resolution of better than one part in 10^8.[12] In a clever piece of thinking and insight, White realised this could be used to measure length changes at the picometre level, and so what has become known as the Three-Terminal Capacitance Method was born, being the heart of a dilatometer for measuring thermal expansion. White's low-temperature expertise combined with the Three-Terminal Capacitance Method, opened up the field of thermal expansion at low temperatures, and his method was adopted by many researchers in the ensuing years. He called his invention the Capacitance Expansion Gauge. His ideas were published initially in September 1960 in a short

[9]For a detailed explanation see Chapter 8, page 153, in White and Meeson (2002).
[10]Barron and White (1999) p. 106.
[11]Thompson (1958).
[12]Thompson and Lampard (1956).

paper in *Nature,*[13] but a detailed description of the development is to be found in a paper published in March 1961 in *Cryogenics.*[14] By those who have reproduced the technique, it has normally been called a Capacitance Dilatometer (for example, Fig. 5).

While Fig. 5 shows that the sample being measured occupied the whole of the length of the low-temperature capacitance cell except for the small capacitance gap, the Capacitance Dilatometer worked equally well for a small crystal or polycrystalline sample, held between a high-purity copper base and a high-purity copper spacer, using light springs.

The study of thermal expansion became White's research passion for the rest of his career. He realised that to make good progress in the understanding of thermal expansion at low temperatures, a larger group studying more broadly the low-temperature thermal properties of solids was necessary. White appreciated that a range of talents was required for building such a research group: theorists needed to understand the challenges and difficulties in performing particular experiments, and experimentalists needed guidance from theorists as to what were the key experiments required to solve theoretical conundrums. At CSIRO he built a world-class group containing a mix of experimentalists, theorists and first-class technicians. All were equal, and thrived under his leadership. White encouraged researchers in his group to carve out their own research niche and to author papers in their own right, to facilitate their career development. This had the added advantage that he would leave, as a legacy, a strong research group that would prosper into the future. The ability to perform experiments at temperatures as low as ~5 mK was achieved in the mid-1980s, when Ron Tainsh, who was present when helium was first liquefied at the NSL in the 1950s, and Chris Andrikidis, constructed a dilution refrigerator. They used a 'tail' unit (the three main parts of a dilution refrigerator; the still, mixing chamber and between them the heat exchangers, but excluding the supporting cryostat structure, dewar assembly, gas handling system and all vacuum components) supplied by Sir Martin Wood, a life-long friend of White's from Oxford and co-founder of Oxford Instruments.

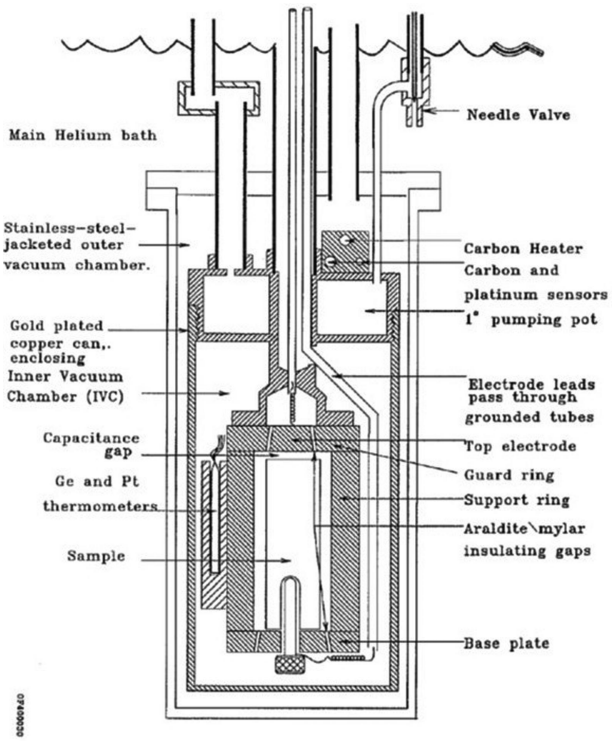

Fig. 5. Schematic drawing of the low temperature section of the Capacitance Dilatometer (diagram courtesy of John Miles).[15]

For a number of years the capacitance bridge marketed by General Radio Company, USA, with a resolution of 10^{-7} pF, was used and this bridge, while being the best available commercially during the 1960s, required manual operation using a series of toggle switches to balance it. Then during the 1980s, as a consequence of a PhD thesis by Carl Andeen at Case Western Reserve University, Cleveland, United States of America, requiring precise measurements of dielectric constant, the Andeen-Hagerling capacitance bridge became commercially available.[16] The resolution of this bridge was better than that of the old General Radio bridge but, more importantly, it could be completely computer controlled in recording changes in capacitance with temperature. White acquired this new bridge for his laboratory.

Many solids were measured, predominantly at low temperatures, and the variation of thermal expansion, often coupled with heat capacity and bulk modulus data to determine a Grüneisen parameter to provide some fundamental understanding of the physics. Materials exhibiting negative thermal expansion over a particular temperature range, such as silica, created particular fascination and gave rise to an important technical application, as invented by Corning for the production of modern stove tops. In 1980, White, in collaboration with Hugh Barron and John Collins, published a seminal review article of the field, in which they discussed the thermal expansion data of many solid-state materials in the range 1–100 K.[17] The extent and significance of this review is revealed by its bibliography of 461 references, and the fact that it is the most heavily cited of White's

[13]White (1960).
[14]White (1961).
[15]Miles (1991).
[16]http://www.andeen-hagerling.com/ah2500a.htm [viewed 20 September 2022].
[17]Barron and others (1980).

publications (at 468 in the online platform 'Web of Science').[18] More significant papers reporting original research by White and his collaborators are the thermal expansion of silicon from 6 to 340 K with 250 citations;[19] the thermal expansion of magnetic metals at low temperature,[20] and the expansion data for copper, silver and gold at low temperatures,[21] both with 177 citations; and, in collaboration with an author of this article (SJC), a paper on the heat-capacity of the reference materials, copper and tungsten with 268 citations.[22] It should be remembered, however, that White's research was not just about publishing articles in scholarly journals. More importantly, it provided reliable physical property data for use by technologists and engineers, in industrial applications.

Low temperatures were not the exclusive focus because high-temperature, thermal-expansion measurements were made on a range of metals and oxides.[23] White was always alert to new and developing trends in solid state physics, and when high-temperature superconductors were discovered in the late 1980s, he quickly joined the effort involving a number of groups, both within CSIRO and externally, to understand these materials.

A feature of White's career was his extensive network of both local and international collaborators. International visitors to the group were always welcome. Two particular visitors should be mentioned. Fred Smith, who had spent several years in the group of Berndt Matthias at the University of California in San Diego, doing research on the pressure dependence of superconductivity, came to the NSL in May 1973, as a senior research acientist, working with White. Together they studied the thermal expansion behaviour of several tetrahedrally bonded solids,[24] and polyoxymethylene,[25] which displayed a negative thermal expansion coefficient over certain temperatures ranges. It was during Smith's time in White's laboratory in Sydney that he re-connected with one of the authors of this article (TRF) who was researching aspects of superconductivity in the Department of Physics at Monash University. Together, in collaboration with White, they undertook some research on the superconductivity and thermal expansion behaviour of the solid solution alloys across the Zr-Nb-Mo-Re system.[26]

In 1974, Smith applied successfully for a senior lectureship in the Department of Physics at Monash where he and Finlayson, aided by much willing advice from White, set up their own low-temperature, capacitance dilatometer, which in their subsequent research on various materials was used in the post-graduate projects of seven students.

The second important international visitor was John Rayne, formerly a colleague at NSL, who had pursued a research career in the United States and was now a professor at Carnegie-Mellon University in Pittsburgh. John had begun research on some linear, antiferromagnetic crystals, such as $CsNiCl_3$, and during a period of sabbatical leave in Australia, 1978–9, he worked with White on the thermal expansion behaviour of these materials,[27] and, at the Department of Physics at Monash University, he assisted in setting up equipment for ultrasonic velocity measurements in order to measure elastic constants of single crystals.

White had some reservations about the relocation of the NML from the grounds of the University of Sydney to Lindfield in the late 1970s, as he felt it would weaken the close contacts with departments at the university, for whom some CSIRO staff were delivering lectures for the enrolled students. Also, he feared a loss of contact with the industries surrounding the university in the Alexandria and Waterloo areas, for whom CSIRO Staff had been providing valuable services for temperature measurement, calibrations and advice on thermal insulation. To him it was a purely administrative decision, firstly on the part of one group in the university, wanting to remove the NSL workshops and secondly on the part of some at NSL, wanting a large space for a high-voltage testing laboratory that he felt should have been constructed by the Electricity Commission of New South Wales. But nevertheless, the move to Lindfield happened, for better or worse.

The physical move of the laboratory from the grounds of the university to Linfield was a major undertaking, taking place over a number of months, and occurred for White on 1 November 1977. Despite his reservations about the relocation, White appreciated the benefits of a new, state-of-the-art, purpose-built laboratory. His group expanded and prospered. He warmed to its location in West Lindfield, on the edge of the Lane Cove National Park. He liked the natural bush setting, with its native fauna and flora, and he led the way in rehabilitating the grounds of the new laboratories with appropriate Australian plants.

For White there was always nostalgia for times at NSL, when it was located at the main campus of the University of

[18] https://www.webofscience.com/wos/woscc/summary/a8def4f2-5d7f-46f1-a950-8436158f5f6b-618a106d/relevance/2 [viewed 9 June 2022].
[19] Lyon and others (1977).
[20] White (1965).
[21] White and Collins (1972).
[22] White and Collocott (1984).
[23] See publications White and Roberts (1980), White (1980), White and Roberts (1983), White (1986) and White (1989) in the journal *High Temperature—High Pressure* listed in the Supplementary Material.
[24] Smith and White (1975).
[25] White and others (1976).
[26] Smith and Finlayson (1976). White and others (1978).
[27] Rayne and others (1981).

Sydney. The NSL building, faced with White Hawkesbury sandstone, and with National Standards Laboratory written large over the front door, still stands, and it is now known as the Madsen Building.[28]

Australian solid state physics

It would be fair to say that White played a significant role in founding solid state physics (perhaps now more commonly termed condensed matter physics) in Australia. Professor Robert Cahn, in his otherwise excellent book, *The Coming of Materials Science,* gives credit to Walter Boas for establishing solid state physics in Australia.[29] Boas arrived in Australia in 1938, taking-up a lecturing position at the University of Melbourne. In 1947, Boas secured a position in the CSIR Division of Tribophysics, located within the grounds of the university, and became division chief in 1949. Whilst Boas presented lectures within the Department of Physics at the university on aspects of crystal physics, the research within his division was mainly concerned with aspects of metallurgy and not what could be broadly termed solid state physics.

The return of White from Canada to NSL in 1958 gave impetus to the newly emerging Australian solid state physics community. In 1960, the first post-war university, Monash University, appointed Professor Robert Street as head of a new Department of Physics in which the research was deliberately different from that at the University of Melbourne, being predominantly solid state physics. This research field was also taken up shortly after at the University of New South Wales and at the Australian National University.

White was active in fostering the development of solid state physics in the Sydney region. He was a contributor and attendee of an informal Solid State Physics Group that met one evening a month at the University of New South Wales. It brought together researchers from the Sydney based universities (and not infrequently those in Wollongong and Newcastle), ANSTO, CSIRO, Defence Laboratories, and some companies that carried out research, such as AWA, for a lecture from a local or an interstate researcher, or an overseas visiting scientist. These meetings were characterised by an informal dinner beforehand and stimulating discussion after the lecture. White gave lectures to senior undergraduates and postgraduates at the universities, and it was at one of these lectures that one of us (SJC) first came to know him, and later join him at CSIRO. For students and young researchers White was always helpful, approachable, and collaborative, being happy to invite the student or researcher into his laboratory if they needed to access a unique piece of equipment, if he possessed it, or to conduct a joint experiment. White's group often hosted early career researchers. In 1978, Ctirad Uher was a Queen Elizabeth II Research Fellow in White's group, and he went on to be the C. Wilbur Peters Professor of Physics at the University of Michigan. White's nurturing of students and mentoring of early career researchers, often by way of providing an introduction to one of his international collaborators, meant that his contributions to the solid state community were not just local, but national and international.

With the advent of more universities in Australia undertaking solid state physics research in the 1960s and 1970s, opportunities were needed for graduate students and early career researchers to present the results of their work at the national level. So, in the 1970s, the idea came to two CSIRO scientists from NML, Drs Rod Day and John Dunlop, while attending a special International Spectroscopy Conference in Perth, that such a national conference should be introduced. Indeed, Rod and John are credited with finding the ideal location for the conference in Wagga Wagga, New South Wales, which, in the 1970s was called the Riverina College of Advanced Education. It could be argued that Wagga Wagga was the 'centre of gravity' for solid state physics research in Australia. TheCollege, situated on the outskirts of town, was an ideal location for such a national conference, with no distractions for attendees to disappear to in the evenings.

White gave his total support to the establishment and continuation of this national conference, the first of which was held in February 1977, and which included visiting scientists and graduate students from New Zealand as well as overseas scientists who were visiting Australian universities and research institutions. The conference, now called the Condensed Matter and Materials Conference, or colloquially 'Wagga', has continued (with a few exceptions) to be held at the Riverina College, which, during the changes to Australian tertiary institutions in the 1990s, became part of Charles Sturt University. The exceptions are the hosting of the conference by New Zealand colleagues, largely due to White's strong advocacy during Wagga 1979. It has resulted in nine Waggas being held in New Zealand. The other has been the incorporation of the Wagga conference into the programme of the Australian Institute of Physics National Congress, which occurred in 1988 in Sydney and 2005 in Canberra. A brief history of the first 39 national conferences was published in 2014.[30]

[28]Sir John Percival Vaissing (Vissing) Madsen (1879–1969) was an Australian physicist and engineer who was the foundation Professor of Electrical Engineering at the University of Sydney and served in this capacity from 1920 till 1949. He had significant involvement with the CSIR laboratories and became a member of the CSIR council in 1944. (https://adb.anu.edu.au/biography/madsen-sir-john-percival-vaissing-vissing-7456) [viewed 22 October 2022].
[29]Cahn (2001).
[30]Finlayson and Stewart (2015).

Fig. 6. Solid State Physicists at Wagga 1985 (L → R): Fred Smith, John Collins, Guy White and Trevor Finlayson (photo courtesy of Trevor Finlayson).

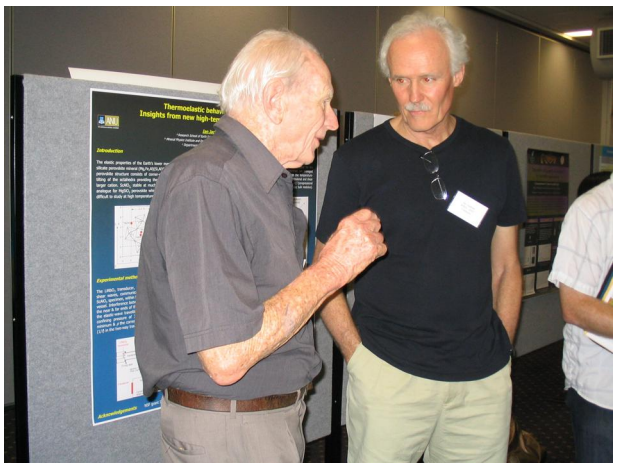

Fig. 7. White in deep discussion with Ian Jackson, Australian National University, during Wagga 2008 (photo courtesy of Glen Stewart).

White attended frequently, for example Figs 6 and 7, and remained a strong supporter of this conference, even well after his retirement. A summary of his contributions is given in the Supplementary Material.

Service to the science community

White was elected as a Fellow of the Australian Academy of Science (FAA) in 1970. Throughout his time as a fellow, he served the academy through its various committees. The details of this service are summarised in Supplementary Material from which it can be seen that his longest service (from 1973 to 1981) was as a member of the Committee on Data for Science and Technology (CODATA) and the Scientific Information Committee. He was also a member of the Academy Council from 1977 to 1980, being vice-president, 1979–80. He is mentioned in the fifty-year history of the academy for his contributions as editor for two Annual General Meeting Symposia' and, in 1985, as a member of a working party to lift the public awareness of science.[31] The initial working party membership was: R. W. Crompton FAA (chairman), R. S. Anderssen, M. R. Bennett, FAA, Louise Crossley, C. C. Heyde, FAA, K. G. McCracken, FAA, P. Pockley, R. Porter, FAA and G. K. White, FAA. Later, in 1988, the working party (now as the Australian Science and Technology Information Service) advanced the media referral service whereby media personnel were put in contact with one or two scientists who were expert in a specific area and able to provide background briefings on current or controversial issues.[32]

White was a Fellow of the Institute of Physics (UK) and a Foundation Fellow of the Australian Institute of Physics, giving service in the New South Wales branch as chair in 1962. During 1991–2 he served as the main external advisor for a review of the Faculty of Science at the University of Wollongong. The review committee was chaired by Dr Barry Jones, who was Minister for Science 1983–90 in the Hawke federal government, and White and Barry came to know each other quite well.

White's contribution to science was recognised by a range of awards and prizes. He was awarded the 1965 David Syme Prize from the University of Melbourne, an annual award to the producer of the best original research in Australia during the two preceding years. Preference is given to work of value in the industrial and commercial interests of Australia.

In 1994, White was awarded the triennial Yeram S Touloukian Award of the American Society of Mechanical Engineers and a Doctor of Science *Honoris Causa*, by the University of Wollongong. When presenting White to the chancellor, Vice-Chancellor Ken McKinnon stated.

> Guy White is a pioneer and internationally recognised expert in the field of low temperature physics. He is acknowledged widely as a perceptive and humane colleague and mentor who is always considerate in his dealings with others. …
>
> Chancellor, when Jacob Bronowski wrote about the values of science, he argued for the centrality of the search for truth and the need for originality and independence of mind. Linked to them, across what he called 'the bridge of tolerance', were the other older values of a scientific society such as 'respect, honour and dignity' (Jacob Bronowski, *A Sense of Future* … . As his fine reputation

[31] Fenner (2005). White (1980). White and Davies (1989).
[32] See Fenner (2005) p. 275.

and his generosity to colleagues and students show, these are indeed values of Guy White, scientist and gentleman.[33]

These are apt sentiments that describe White well. In 2000, White was appointed to the Order of Australia in the General Division (AM), the citation for which read as follows: 'For service to low temperature physics, particularly as a former Chief Research Scientist with the CSIRO, and through scientific publications and teaching.'[34] He was also awarded a Centenary Medal in 2001.

Though White was a senior scientist in CSIRO, he did not seek leadership positions. Some thought he should have. This was not because White thought leadership positions were unimportant, but rather, he felt the best and enduring contribution one could make was by good science. It was science that mattered. A biography littered with references of competence in CSIRO Excel Spreadsheets and CSIRO's arcane bureaucratic ways, was of little value compared to one populated with publications in high-quality journals or invited talks at international conferences. White did worry about the health of Australian science and he thought this was best addressed by being an active member of the Academy of Australian Science.

Life outside science

In White's early years he had grown to love the Australian bush and was an accomplished horseman. It has been reported that shortly before he was due to depart for the University of Oxford, he contacted the father-in-law of a friend he knew from his time in the Hunter Valley, with a plan to ride up and over the Great Dividing Range and down the other side. While he was definitely excited about going to Oxford, he wanted to 'go bush' first. This appreciation of the outdoors remained with Guy throughout his life so that bushwalking with family and friends (Fig. 8) was an enjoyable pastime.

He was a founding member of the CSIRO Ski Club, having been taught to ski by Bob Arnott at the University of Sydney, who was both a champion skier and a classical pianist. White assisted with the building of the club's lodge at Perisher. In return, White taught Bob how to surf (body surf, not board), a relaxation activity that continued for White as a member of the Rose Bay Surf Club—actually a private surf club in Bondi. Unfortunately, damage to his shoulder in his later years, brought this activity to an end.

Retirement—scientific activities (1990–2009)

White officially retired from CSIRO as a Chief Research Scientist in 1990, and became a CSIRO Honorary Fellow.

Fig. 8. Bushwalking on Ramshead Range, Mt Kosciuszko National Park: (L → R) Guy White, Harding Burns, Mary Burns and Judith White (photo courtesy of Guy White's family).

What followed was a very active retirement. He continued to attend national and international conferences, serve on the editorial boards of both *Cryogenics* and the *International Journal of Thermophysics*, something he had been doing for many years.

He also remained an active member of the academy and contributed to a Landolt-Börnstein volume published by Springer-Verlag.[35] This volume represented a huge commitment to reviewing the complete literature covering the electrical and thermal conductivities of pure metals, metal alloys, semi-metals and their alloys, and compiling the data in both tabular and graphical formats, in such a manner to be useful to non-experts in the field, requiring such data for engineering applications. The volume contained a clearly written introduction to enable a non-expert not only to use the data presented, but also to understand the underlying physics of electrical and thermal conduction, involving the roles of the electrons, lattice vibrations and defects. This is an example of White's clear thinking that always made a scientific discussion with him invaluable. White's particular contribution was chapter 2 (12pp.), which summarised thermal conductivity data for pure metals and alloys at room temperature, over temperature ranges above 50 K and also at low temperatures.

A major interest was analysing and evaluating data, which resulted in the compilation of reference thermophysical data on technical and engineering materials with CODATA (a member of the Committee on Data for Science

[33] https://documents.uow.edu.au/content/groups/public/@web/@alumni/documents/doc/uow230540.pdf [viewed 20 September 2022].
[34] https://en.wikipedia.org/wiki/2000_Australia_Day_Honours [viewed 20 September 2022].
[35] Madelung and White (1991).

Fig. 9. Guy and Belinda at his 90th birthday celebration at the Emerald Hotel, South Melbourne (photo courtesy of Stephen Collocott).

and Technology (CODATA) from its formation in 1973, until its reincarnation as Scientific Information in 1981).[36]

It was also during retirement that he authored, in collaboration with Hugh Barron, University of Bristol, his second book, *Heat Capacity and Thermal Expansion at Low Temperatures*, published in 1999.[37] On the authors' own admission, this monograph resulted partly due to the persistent efforts of the general editor of the monograph series, Dr Klaus Timmerhaus, who persuaded them to encapsulate their research on the thermal properties of solids, conducted over many years, before they either expired or became totally senile. The book recognised the need for a reference text on heat capacity, thermal expansion and elasticity, which are all closely linked thermodynamic properties. It is a very practical text with discussion of basic theory, measurement techniques, and classes of solid materials—metals, polymers, glasses, ceramics, and mixtures thereof. It contains useful tables of thermophysical property data. An understanding of thermophysical properties and high-quality thermophysical data are necessary for applications in the space industry, telecommunications, energy conservation, astronomy, and medical imaging, among others.

For a short time around 2000, White had a visiting scientist position in the Research School of Physical Sciences at the Australian National University where he met Belinda Lamb. White and Lamb moved to Hobart in 2001, living in a house within walking distance of Bellerive Oval and overlooking the River Derwent. They were married in 2005.

Concluding comments

White was of a generation that had a memory of the grim times of the Great Depression, and these in many ways moulded how he lived his life. He was decent and considerate, and not driven by a quest for material wealth. White felt no need to update an appliance or car if it could be easily repaired or was functioning well. His time at Oxford was the seed that led to a wonderful career. He was fascinated by the wider world. When attending an international conference White would say: 'make sure you get out of the conference venue to experience the local culture and landscape'. He loved the Australian landscape and going bush. White enjoyed chatting on what was going on in the world, but rarely, if ever, talked politics. This does not mean he was not interested in politics. He was interested in good policy in areas where he felt he could make a contribution, such as science, education and manufacturing, not so much political practitioners.

His 90th birthday (Fig. 9) was celebrated with a number of friends in fine style, at the Emerald Hotel South Melbourne, on 31 May 2015, with White's favourite entertainment, a quality jazz band.

[36] Fenner (2005), p. 404.
[37] Barron and White (1999).

Supplementary material

Supplementary material is available online.

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