

Physics in Adelaide

The 1960s

Alastair Blake

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When Professor Huxley resigned from the University of Adelaide's Elder Chair of Physics at the end of 1959, Stan Tomlin was made Acting Head of the Department. It was at this time that a Departmental Committee was established, beginning a University movement toward departmental government. Stan planned to apply for appointment to the vacant Elder Chair and began research work in solid state physics as an initiative that would strengthen his application. Soon a group of postgraduate students had begun projects in this area and the 1960s began with new activity in experimental physics research that was a compensation for the loss of the slow electron diffusion work that Huxley had taken with him to the Australian National University. In the Department of Mathematical Physics the 1960s began with the appointment of Ian McCarthy to a lectureship.

Solid state physics

The pioneer of the solid state laboratory was Bob Lawrance. He graduated in physics from the University of Western Australia and in 1957 he completed an MSc with Stan Tomlin on the photoconductivity of vacuum evaporated films of cadmium sulphide. In 1959 he was appointed as a lecturer in the Department and began a PhD project on the role of electron traps in thin films of cadmium sulphide. He was interested in solid state devices that use surface effects. He completed his thesis at the end of 1964.

Don Griffin began a PhD at about the same time. He was an Electrical Engineering graduate and had an interest in the use of solid state devices as components in microwave systems. When he was appointed to a position at the South Australian School of Mines and Industries in 1959 he enquired about undertaking a PhD with Stan Tomlin because he knew of Stan's work with microwaves during World War II. He developed equipment for the vacuum deposition of thin semiconducting films and searched for materials exhibiting a strong Hall Effect at microwave frequencies that would have potential application in practical devices. Don later had a long career in the University's Department of Electrical Engineering.

Another group of students began PhDs after completing Honours in the Department. They moved into empty laboratories and set about equipping themselves for their projects. Stan Tomlin provided guidance, encouragement and resources, but not close supervision. The students enjoyed the freedom to find their way and they had a sense of being pioneers together. Brian Cavenett built a superheterodyne spin resonance spectrometer using a large Newport magnet that Stan had acquired. It was only the second such instrument in the world and was a masterpiece of valve electronics. Brian was joined by Peter Burley. Peter contributed little to the experimental part of the project, instead devoting himself to learning the group theory and quantum mechanics required to interpret the electron spin resonance spectra. A 'bomb' was built in which crystals doped with appropriate materials could be grown at high temperature and pressure. They were a good team and two good theses came out of it. Brian Cavenett went to the University of Hull. Peter Burley graduated in economics while undertaking his PhD in physics and went to the United States where he pursued an academic career in economics.

Don McCoy and Gault (Jack) Antcliffe set up their experiments in another laboratory with Bob Lawrance. Don had been a cadet working with Dr Burdon and Clem Appelby, who supervised the undergraduate laboratories. As a cadet Don took an extra year to complete his undergraduate degree and had experiences that included experimenting with a Wilson cloud chamber and restoring the old Finch electron diffraction camera to working condition. Like many of the Departmental cadets he became a talented experimentalist. Following his Honours year in 1960, Don embarked on a PhD program to make meticulous measurements of the electrical and optical properties of thin films of carbon. The interpretation of his data confronted him with messy equations involving the complex refractive index. It was not practical to make multiple inversions of these equations by hand, but fortunately the University acquired its IBM 1620 computer at that time. Jack Antcliffe developed another experimental system to study electroluminescence in thin evaporated films of materials such as zinc sulphide.

After this initial flurry of activity the pace slowed. Although Stan Tomlin recruited a few more students into the solid state laboratory, the work had largely run its course by the end of the 1960s. However, for a decade the Solid State group was a very successful centre of research in experimental physics.

Biophysics students

During the 1960s Harry Medlin supervised biophysics projects by two postgraduate students whom he regarded as his most outstanding: Brian Matthews and Peter Colman. Both went on to have distinguished careers, becoming pioneers in study of the structure of proteins.

Brian Matthews determined the structures of two organic crystals by X-ray diffraction. He too was aided by the arrival of the IBM 1620 computer, but only after he had spent many tedious hours toiling with trigonometric tables and a Marchant mechanical calculating machine. Brian completed his PhD in 1963 and went to postdoctoral positions, first at the Medical Research Council Laboratory of Molecular Biology, Cambridge, England, where he was involved in the early days of protein crystallography, and then at the National Institutes of Health in the United States. In 1970 he was appointed Professor of Physics at the University of Oregon. There he created hundreds of mutants of an enzyme known as T4 lysozyme, determined their structure by X-ray crystallography and measured their melting temperatures. This work provided the basis for the investigation of fundamental problems in biology for which he rapidly won recognition. Notable among these problems were the stability of the three dimensional folding of proteins, the interactions between proteins and the mechanism by which enzymes act as catalysts. The work of his Institute of Molecular Biology was recognised with the award of a DSc by the University of Adelaide in 1985 and his election to the US National Academy of Sciences in 1986. He is editor of the Protein Society journal *Protein Science*.

Peter Colman also determined the structure of two organic compounds. After completing his PhD in 1969 he went to the University of Oregon to work with Professor Brian Matthews, his predecessor in Harry Medlin's laboratory. Then he spent some time at the Max Planck Institute, Munich, before returning to Australia in 1975 as a Queen Elizabeth II Fellow at the University of Sydney. There he worked on the structure of crystals of an influenza virus. In 1978 he joined the CSIRO Division of Protein Chemistry to form a crystallography group with emphasis on the structure of globular proteins. The influenza virus neuraminidase became his major interest. Peter and his colleague Jose

Varghese produced improved crystals of the virus and in 1983 solved its three dimensional structure using X-ray crystallography. Furthermore, they identified a small region in the neuraminidase protein that occurs unchanged in all strains of influenza. This was the key to the design of a drug that locks onto the influenza virus and inhibits its development. This design led to the commercial development of the anti-influenza virus drug Relenza by the Melbourne based company Biota Holdings Ltd and subsequently of Tamiflu by a US-based company. This was the first time that a clinically effective drug had been designed with a computer. Peter was a founding member of the Board of Directors of Biota Holdings and also of the Board of Directors of Starpharma Ltd, another Melbourne based pharmaceutical company. In 2001 Peter moved to the Walter and Eliza Hall Institute of Medical Research where he is Head of the Structural Biology Division. He was awarded an Australia Prize in 1996.

Harry Medlin took special delight from the careers of his students, but he was a university person in the broadest sense. He was a passionate educator and his lectures were a fascinating experience with frequent excursions into philosophical matters. He introduced a physics course for arts students that he called 'Physics, Man and Society' and was disgusted when the name was later changed to 'Physics, Ideas and Society'. He served as a member of the Education Committee for many years and from 1980 to 1982 he was the inaugural Chairman of its Executive Committee. He was elected to the University Council in 1967 and served as a member until 2006, long after his retirement. Harry knew every rule, every standing order and every regulation under the University of Adelaide Act and would quote them to send University secretaries running to check. He was the corporate memory of the University, and could quote precedents that predated every Chancellor and Vice Chancellor. He was Deputy Chancellor from 1978 to 1997. Harry always had an interest in alumni affairs and, perhaps because of his wartime experience, Harry always had a special interest in South East Asian alumni, many of them Colombo Plan students who had gone home to become distinguished leaders in business, politics, science and the arts. He was a strong supporter of the Adelaide University Union in its provision of student facilities and of the University Theatre Guild. As president of the Theatre Guild he was responsible for world premieres of plays by John Hepworth, Hal Porter, Alan Seymour and Patrick White which were performed in the Union Hall. Harry regarded Union Hall as a sacred site and its recent demolition caused him much anguish.

Harry retired in 1985. In 1987 he was awarded the degree of Doctor of the University and in 2001 the Centenary Medal. In his later years he suffered from a recurrence of post beriberi neuropathy, but he continued to be provocative in his views and steadfast in his defence of what he believed to be right, causing Michael Abbott to remark that he was a fighter against hypocrisy and the bane of fence sitters in general and sycophants in particular. Harry died in March 2013.

Computational work in Mathematical Physics

In March 1960, Ian McCarthy took up an appointment as Lecturer in the Department of Mathematical Physics. After completing his PhD on quantized field interactions with Bert Green, Ian went to Cambridge University in October 1956. Two years later he went to postdoctoral positions at the University of Minnesota and then the University of California, Los Angeles. During that time, he undertook quantitative computational work in theoretical nuclear physics based on the phenomenological nuclear optical model. These were among the first physics computations using the newly invented FORTRAN language. This was very different from the highly mathematical thesis work he had done with Bert Green. At UCLA Ian had close association with an experimental nuclear

physics group. They were building a cyclotron and in his discussions with them Ian formed the idea that a cyclotron should be built in Australia to put it in the front line of nuclear physics research.

At the University of Adelaide, Ian supervised a group of very able graduate students: Ken Amos, John Corbett, Lindsay Dodd and Lim Khaik Leang from Malaysia. Except for Lim, they were members of the 1960 Honours class and had been part of a group who liked to be known as the 'Beagle Boys', a rather rowdy lot noted for their boisterous dinners. Much of the thesis work of Ian's students reflected his interest in quantitative computational study of nuclear reactions. Ian had brought with him several of his FORTRAN programs which, for their time, were large and complex. Ken Amos worked on one of them to investigate the distorted wave Born model for nuclear reactions. Lim developed a large program for knock out reactions such as the $(p,2p)$ reaction. Lindsay Dodd wrote a program for the statistical model of compound nuclear reactions and then undertook work of a more formal mathematical nature concerning reaction times in nuclear collisions. John Corbett worked on a more mathematical project in quantum mechanical scattering theory.

For their computations, these students had access to the state of the art IBM 7090 computer that had recently been installed by the Weapons Research Establishment at Salisbury (WRE). These were the days when computer programs were punched on cards. The boxes of cards were delivered to the computer and the printed output was collected on another day. There was considerable incentive to avoid programming mistakes as just one typing error could result in days of lost time.

As powerful computers became more accessible, computational work became a normal tool of theoretical physics, but Ian's phenomenological approach was a new style of work for the Department of Mathematical Physics. It was a different approach to understanding physics, a different part of the spectrum of theoretical physics, in which models of nuclear processes were used to compute quantities that can be measured experimentally. It contrasted with the Green/Hurst approach of seeking understanding that is based in formal mathematics.

Angas Hurst was always essentially a mathematician and never came to terms with computers as a research tool. However, he was a great listener and supporter of the Department's students. All of Ian's students benefited from interesting and helpful discussions with Angas that are acknowledged in their publications. On the other hand Bert Green did develop an interest in computing and wrote programs for the University's IBM 1620 computer. Lindsay Dodd remembers a program Bert wrote to find the eigenvalues and eigenvectors of complex matrices. Characteristically Bert had reduced the problem to the minimum number of steps with many logical branches, no subroutines and no explanatory comments. Like so much of Bert's work, it seemed to spring out of his mind already formed and was very hard to follow.

Ian pursued the work on nuclear reactions in nuclei with his characteristic enthusiasm. In the United States he had experienced physics as a shared activity and that became his approach for the remainder of his career. He was a gregarious person and encouraged students to take lunch as a group and discuss their problems with each other. For his students, the impact of Ian's personality was almost more important than the work he was doing.

It was not long before Ian became restless. He believed that to be internationally competitive he needed close collaboration with an experimental nuclear physics group that had access to

adequately high particle energies. He campaigned for funding to build a suitable cyclotron, but when nothing came of it he concluded that he must return to the United States. In 1963 he took up a tenured position at the University of California, Davis, where the construction of a large cyclotron was planned.

However, Ian was again frustrated because those plans failed and in 1965 he accepted the position of Professor of Physics at the University of Oregon. While there his book *Introduction to Nuclear Theory* was published. Then, in 1967, Flinders University advertised a second chair of physics and a colleague encouraged him to apply. He was appointed and it was at Flinders that Ian at last achieved close association between his theoretical computational work and an experimental program but, as we shall see, it was in atomic rather than nuclear physics.

The Carver years begin

It was John Henry Carver who was appointed to fill the Elder Chair of Physics that Professor Huxley had left vacant. Carver was born in 1926 and grew up in Sydney. His wife sometimes refers to him as John Henry to distinguish him from a long line of ancestors with the name John Carver, and later from his son and grandson.

John won a scholarship to the University of Sydney and studied there during the latter years of World War II when physics was an important and glamorous subject. In his third and fourth years, John received a good grounding in atomic and molecular physics that was to serve him well later when he was appointed to the Elder Chair in Adelaide. Then, in his MSc year, he was introduced to research in nuclear physics and had a project that involved the construction of Geiger counters.

As he considered the next stage of his education Carver's supervisor, Victor Bailey, drew his attention to the Australian National University's study abroad scholarships. He applied for one, was successful, and in 1949 went to the Cavendish Laboratory at Cambridge University. Lawrence Bragg was then head of the Cavendish and Otto Frisch was head of Nuclear Physics. John chose as his PhD supervisor Denys Wilkinson, a brilliant scientist only a few years his senior. He studied photodisintegration of the deuteron using γ -rays produced with the aid of a 1 MeV Cockcroft-Walton generator and a high pressure deuterium filled proportional counter he constructed. The counter had a very fine wire suspended from the top and held taught by a plumb bob. His supervisor later told of an occasion when, as John was moving the counter to the experimental area, the delicate wire snapped. His reaction was just to say 'start again' – an example of the imperturbability that characterised his career.

In 1953 Carver returned to Australia as a Research Fellow in the ANU Department of Nuclear Physics which was then led by Ernest Titterton. Here he had access to a 33 MeV Cockcroft-Walton electron synchrotron and continued his study of photodisintegration. In 1958-9 he took leave at the Atomic Energy Research Establishment at Harwell in the United Kingdom and extended his work to the inverse process of radiative proton capture. After his return to the ANU he was promoted to the tenured position of Fellow and then, in 1960, to Senior Fellow.

At about this time John Carver again began to consider his future and it was Mark Oliphant who urged him to apply for the Elder Chair at Adelaide. Although John was not part of Oliphant's

Department of Particle Physics, a special lifelong affinity had developed between. A decision to act on his mentor's advice required careful consideration. There were no facilities in Adelaide with which he could continue research in nuclear physics and, although the exciting prospect of discoveries with a proton synchrocyclotron at ANU was dashed when that project was cancelled, the ANU was acquiring more powerful particle accelerators. However, Oliphant pointed out the research opportunities afforded by the proximity of Adelaide to the Weapons Research Establishment at Salisbury and the rocket range at Woomera. The idea emerged of making a radical change of research career from nuclear physics and mounting a program of atmospheric research using rockets supplied by WRE and launched from Woomera. John made the bold decision to apply for the position and the University made the bold decision to appoint him.

When he arrived in Adelaide in August 1961, Carver found himself in charge of a department in which he was one of the younger staff members. Nevertheless, taking charge was something he did confidently and firmly but gently. Harry Medlin took him to the Richmond Hotel for a chat and urged him to work with the Departmental Committee that Stan Tomlin had established. Carver agreed and soon developed leadership skills for Departmental government very different from those required of the traditional professor. He soon had the knack of getting from the Committee the decisions he sought without the Committee ever doubting that it had made the decisions.

After his arrival in Adelaide, John Carver had two urgent matters to attend to in establishing his proposed program of upper atmosphere research. First, he had to establish a relationship with WRE and secure the rocket facilities he needed. He also had to immerse himself in what was, for him, a new field of research and learn how it was to be done.

It was not obvious that negotiation to obtain rockets to carry instruments into the upper atmosphere would be successful. Just a few years earlier, the university sector had failed to secure rocket flights as part of the Australian contribution to the International Geophysical Year and then in 1960 the Australian Government had shown total lack of interest in space research by rejecting a US offer to launch a research satellite. However, from his experience at Harwell, John knew that the academic and defence cultures could work together. John visited Robert Boswell, Director of WRE, and John Knott, Secretary of the Australian Department of Supply. After careful discussion they accepted his proposals for a collaborative program in which sounding rockets carrying Physics Department instruments would be flown into the upper atmosphere. It is remarkable that Carver succeeded where others had failed. Perhaps it was an early example of what became a trademark ability to persuade people not just that they could do something for him, but that it was in their best interest to do so.

To introduce himself to his new research field, John Carver began attending meetings organised by the Committee on Space Research. COSPAR was established by the International Council of Scientific Unions in 1958 following the launching of the first Earth satellite by the Soviet Union. It had the purpose of promoting international cooperation in space research. Eight months after he arrived in Adelaide, Carver went to the third annual COSPAR Assembly in Washington, DC. While he was there he visited the NASA Goddard Space Research Institute and the US Naval Research Laboratory. Both laboratories had groups that were leaders in the field of rocket-borne observations of solar ultraviolet radiation, and after those visits John felt that he knew what he had to do and how to do it. Furthermore, he was confident that his new research program could be competitive in the

field. At the COSPAR meeting he met many physicists working in upper atmosphere work. He was getting to know and to be known by the upper atmosphere research community. This was the first of 22 COSPAR Assemblies that John attended.

Carver also set about persuading some Honours graduates that their best interest lay in a PhD project involving the risk of a rocket misfiring or of instruments failing to operate in the critical seconds of their flight or of the telemetry system failing to relay data. His proposal was to develop simple detectors that could be used to observe the absorption of extreme ultraviolet solar radiation in the atmosphere. Each detector would be sensitive to a small range of wavelengths principally absorbed by a single component of the atmosphere so that the density profile of a particular atmospheric gas could be deduced. He chose to concentrate on two atmospheric gases: molecular oxygen and ozone.

The first postgraduate student to embark on the program was Peter Mitchell. While a student of the Adelaide Teachers College, Peter had taken advantage of an arrangement that allowed him to complete a BSc and then Honours in physics at the University of Adelaide. He taught high school physics for two years and at the end of 1961 discussed options for a PhD project with the newly arrived Professor Carver. Carver promptly persuaded him to begin a project that involved developing a set of small gas-filled ion chambers suitable for making observations of absorption by molecular oxygen. By the middle of the year Carver returned from his trip to the United States with a sample of the miniature ion chambers being used for rocket work there. A scanning vacuum ultraviolet monochromator was acquired to calibrate the ion chambers. Design of the electronics associated with the UV detectors was undertaken by Eric Murray who had developed expertise in electronics while undertaking a PhD in the meteor radar group. Carver appointed Eric to a lecturing position in 1962 and persuaded him to join the new research group. Eric provided expertise in electronics to the Department until he left to take up an appointment at Flinders University in 1966.

Because the solid fuel sounding rockets subjected the instruments to a very high acceleration at launch, making the equipment rugged enough to survive the launch was a considerable challenge. The technical skills of Bob Hurn, Phil Stevenson and Alan Suskind enabled these difficulties to be overcome and the first of the ion chambers were flown in December 1963, just two years after Carver had arrived in Adelaide. They were launched on HAD 301, a small two-stage rocket that reached an altitude of about 90km. These rockets had been developed by WRE for the High Altitude Density Falling Sphere Project. A second flight five days after the first suffered a vehicle fault and no data were collected. A third flight, on a somewhat larger Long Tom rocket, was also unsuccessful due to failure of the telemetry system. The first publication from this work came in 1964 and Peter's PhD thesis followed in early 1966.

One of Carver's first appointments was Roger Bell who took up a lectureship in 1962 after completing a PhD in astronomy at the ANU. Roger was a spectroscopist and John hoped that he would find a place in the work on solar ultraviolet radiation. However, by the end of the year Bell had accepted an appointment at the University of Maryland where he had a long and distinguished career as an astronomer.

The second aspect of the upper atmosphere program was to make measurements of the night-time ozone density profile. Again the extinction of ultraviolet radiation would be observed but this time

the source was solar UV scattered by the full moon. Photometers were developed that had a narrow band filter and a photomultiplier tube to provide the required high sensitivity. Two years after the launch of HAD 301 the ozone photometers were flown, again on a HAD rocket.

Further rocket flights followed, and by 1977 there had been some twenty flights on HAD, Long Tom, Cockatoo, Skylark and Aerobee rockets making measurements of atmospheric oxygen and ozone density profiles and the lunar reflectivity. As well as the University participants, scientists from WRE took part in the project. They included Brian Rofe, who was the main contact with WRE, and Barry Hunt, who performed calculations on the formation of ozone in the atmosphere.

The ozone work was undertaken by Brian Horton. Brian grew up in Queensland and had worked as a jackeroo, trained as a police cadet, worked at the Mount Isa mines and had been a warder at Brisbane's Boggo Road Gaol. While working at the gaol he undertook an adult matriculation program and had coaching from an inmate doing life for murder. After matriculating Brian enrolled at the University of Queensland and graduated with Honours in physics in 1962. He was then employed by WRE as a Scientific Officer at Woomera before enrolling for a PhD at the University of Adelaide and being employed as a Tutor in the Department of Physics. In 1970 Brian was appointed to a lectureship and came to be well known among students for the way he prohibited chatter during his lectures with a strictness that was reminiscent of his former career in Brisbane. In 1968 he completed a PhD thesis based on the night-time ozone measurements, observations of the ultraviolet reflectivity of the moon and his work as Coordinating Scientist for Australia's first satellite.

An Australian satellite

This exciting opportunity arose at the end of 1966. Project SPARTA, undertaken jointly by the United States, the United Kingdom and Australia to study high speed re-entry into the atmosphere, was concluding. One modified Redstone rocket remained unused and the United States offered to launch it for WRE with the qualification that the launch must occur within a year. It was quickly agreed that the rocket would be used to place a satellite into orbit. WRE would build the satellite, to be known as WRESAT, and the Physics Department would provide its already proven sensors to make measurements of the upper atmosphere and the solar spectrum.

The satellite instrumentation included two sets of three ultraviolet ion chambers sensitive to different wavelength bands for molecular oxygen measurements, a hydrogen Lyman- α telescope, a photodiode sensitive to a band around 2,500 Å for ozone measurements, a Geiger counter to measure solar X-rays with a wavelength around 8 Å, solar aspect sensors and a magnetometer. Measurements were planned to be made continuously in sunlight but particularly near 'sunrise' and 'sunset' on each orbit. Observations of hydrogen Lyman- α radiation scattered from the anti-solar direction would also be made.

After eleven months of hectic preparation the satellite was completed. It was brought to the University for testing in the large stainless steel space simulation chamber that Carver's laboratory had acquired for the purpose. This chamber was installed and operated by Euan Mackenzie, who had been appointed to a lectureship in 1965 after completing a PhD in Birmingham, and John

Wright, a Space Group technician. Euan had experience flying Langmuir probes on Skylark rockets and he was a keen pilot, proud of his training with the RAF.

Three days before the satellite was taken to Woomera for integration with the rocket, the satellite electronics malfunctioned. It was a tense time because the launch could not be delayed, but after some deft technical work the problem was resolved. On 29 November 1967 WRESAT was launched into a near polar elliptical orbit with a perigee of just 198 km. Australia had become only the fourth nation to launch a satellite from its own soil.

Some bystanders thought that it was a pity to put so much effort into a satellite with instruments that were powered by batteries. But, given the time and resources available, there was no alternative. The instruments operated perfectly for 5 days, producing a large amount of data, and after just over 6 weeks WRESAT re-entered the atmosphere.

The X-ray detector on WRESAT was developed by Paul Edwards and Alan Gregory who had both been appointed to lectureships in 1964. Paul arrived in Adelaide after completing a PhD thesis on the study of cosmic rays at the University of Tasmania. Alan had graduated from University College, London, at its Exeter Campus in Devon and then undertaken a PhD in nuclear physics at ANU where he met John Carver. He came to Adelaide after a postdoctoral appointment at the University of Reading. Paul and Alan flew their Geiger counters on a Long Tom rocket about 12 months before WRESAT was launched. The tiny Geiger counters were not sensitive enough to detect X-rays from stellar sources and only solar X-rays were observed. Because the 8 \AA radiation detected by the counters is absorbed by all atmospheric constituents, the data could be used to determine the total atmospheric density profile. The Long Tom flight was timed to coincide with an overpass of Explorer 30, a US Naval Research Laboratory satellite that made measurements of solar radiation, so that a comparison could be made with the satellite data.

Photoabsorption in the laboratory

There was another aspect to the program of research that Carver had proposed to the University. It was a laboratory study of the absorption of ultra violet radiation by atmospheric gases, intended to provide the cross-section data needed to interpret data from the rocket flights and also to reach new understanding of the fundamental photoabsorption processes. It was begun by two graduates of the 1962 Honours class working under the supervision of John Carver. Gerald Haddad undertook the measurement of total photoabsorption cross-sections and band oscillator strengths in the molecular UV spectrum. Alastair Blake began by measuring total photoionisation cross-sections, but he then constructed a photoelectron energy analyser that allowed him to make the first measurements of partial photoionization cross-sections for particular final states of the ion. All these measurements were made using a second, larger, vacuum UV monochromator.

Gradually the range of projects undertaken in the 'Space Laboratory' expanded. Measurements of the optical properties of evaporated metal films and mineral surfaces were undertaken by Ted Sandcock who was a student of the Adelaide Teachers College and had been a member of the 1959 Honours physics class. The mineral measurements were used to interpret the lunar reflectivity that had been measured in the rocket program.

Peter Teubner also undertook teacher training and he taught at Findon High School for two years after completing Honours in physics in 1960. At the beginning of 1963 he began a PhD. His supervisor was Erich Weigold who had graduated from the University of Adelaide and undertaken a PhD in nuclear physics at the ANU where he knew John Carver. Erich persuaded Peter to undertake measurements of the angular distribution of low energy electrons scattered elastically by a range of atoms, including hydrogen. He believed that the atomic cross-sections would be larger and more easily measured than those of the nuclear reactions he had studied. However, measuring scattering from atomic hydrogen proved to be technically a very demanding assignment. To make matters worse, Erich announced early in 1964 that he was leaving to take up an appointment with the US Airforce Office of Scientific Research in Washington DC. At about the same time Peter was joined by another postgraduate student, Kevin Williams, who had been a member of the 1958 Honours class with Erich Weigold. Although Peter and Kevin had a somewhat argumentative relationship, it was Kevin who developed a sophisticated phase-sensitive detector that was the key to the success of their project. Between them, they made landmark measurements of the differential scattering cross-sections for several atomic species.

While he was in Adelaide Erich met Ian McCarthy and they discussed an idea Ian had for an electron scattering experiment. Before leaving UCLA to return to Adelaide in 1960, Ian had published a paper with two colleagues in which they developed a representation of nuclear states in terms of linear momentum. At the end of the paper they speculated that the technique could be applied to atoms and molecules. This led Ian to wonder if study of the $(e,2e)$ reaction, in which an incident electron knocks out another electron in an inelastic scattering process, might yield understanding of atomic structure analogous to the insights that the $(p,2p)$ reaction had provided about nuclear structure. Later, at Flinders University, those discussions came to fulfilment when Erich and Ian began a productive collaboration.

In 1965 Keith Lokan was appointed Lecturer. He too was a graduate of Adelaide University and the ANU where he had published papers with John Carver. He joined the Space Group and took an interest in both the rocket program and the laboratory experiments, providing helpful guidance to postgraduate students. In 1967 he left to become Director of the Australian Radiation Laboratory in Melbourne.

These were exciting times, reminiscent of the period following the arrival of Professor Huxley. In both cases able Honours graduates were set the task of establishing new lines of research and allowed considerable freedom in doing it. John Carver maintained a close interest, gave general direction and provided helpful encouragement.

In 1968-9 John took 12 months of study leave and went to work with Talbot Chubb at the US Naval Research Laboratory in Washington, DC. Chubb led a program of upper atmosphere research using balloons, rockets and satellites. There Carver was able to look back on a decade in which he had achieved the objectives he had outlined at his interview for the Elder Chair: to mount a program of rocket-borne observations of the atmosphere in cooperation with WRE and to establish a diverse program of related laboratory measurements. The projects had developed quickly and successfully, many papers had been published and by the end of the 1960s ten PhDs had been completed.

The years of the 1960s were a time of intensive space exploration that followed the launch of Sputnik and climaxed with the moon landing in 1969. Carver immersed himself in space research and became well known and respected around the world. In 1970 he was elected Chairman of the United Nations Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, following the sudden death of the previous Chairman who had also been an Australian: David Martyn, Officer-in-Charge of the CSIRO Upper Atmosphere Section and President of the Australian Academy of Science. When he arrived at the United Nations, John found that a flurry of diplomatic activity had secured agreement from the Italian and Indian delegates to nominate him to be Chairman of the Subcommittee. He soon discovered too that all discussion there was laboured and embroidered with polite references to members as 'the distinguished delegate from ...'. Decision making was slow. However, he adapted to it and served in that role for the next 26 years. During those years the leadership skills that John had honed in his Department in Adelaide served him well. These skills were particularly evident in the wake of the contamination of the Canadian wilderness by a re-entering Soviet satellite. John chaired the UN discussion of that incident and the subsequent negotiation of international principles for the use of nuclear power sources in outer space. The Secretary General of the United Nations, Boutros Boutros-Ghali, was impressed

Radiophysics renewed

Before Professor Huxley came to Adelaide from Birmingham in 1949 he had collaborated on ionospheric research with Jack Ratcliffe of the University of Cambridge. When he arrived in Adelaide Huxley initiated work in that area which was taken up by Gordon Aitchison, a lecturer in the Department, and then by Geoff Goodwin, a postgraduate student. They completed a PhD and an MSc respectively on observations of self-demodulation of a radio wave in the ionosphere. Soon after Professor Carver arrived in Adelaide, Gordon left to take up an appointment as Senior Lecturer in Physics at the ANU. In 1962 Carver made an appointment that was to put the Department of Physics at the forefront of ionospheric research.

Basil Briggs was born in Bradford, England. He won a scholarship to the University of Cambridge and graduated in 1941. Then, until the end of World War II, he worked with the Telecommunications Research Establishment and gained skills in radio science. After the war he returned to Cambridge, joined the Radio Research Group of the Cavendish Laboratory and in 1952 gained a PhD under the supervision of Jack Ratcliffe. Basil stayed at the Cavendish and worked on a mathematical procedure to deduce the horizontal motion of the ionosphere from radar signals detected with a set of spaced antennas. By 1961 Ratcliffe had left Cambridge, the Cavendish Radio Group was declining and Basil looked around for a post in another university. He applied for the senior lectureship in physics that the University of Adelaide had advertised and was appointed.

When he arrived in Adelaide, Basil obtained a grant from the US Airforce Office of Scientific Research and began radio studies of the ionosphere from a site near Salisbury. Basil was interested in observing the horizontal drift of irregularities in the ionosphere, and about a year after arriving he made a proposal to build a major new facility for this work. Earlier observations with three closely spaced antennas were often ambiguous because of the continually changing form of the ionospheric irregularities. Basil's idea was to remove the ambiguity by building an antenna array large enough to encompass several maxima of the diffraction pattern produced on the ground by back-scattering of radio pulses from a nearby transmitter. Such an array needed to be at least 1 km across. Basil and Graham Elford set about designing a suitable array and decided on a circular shape 1 km in diameter

with 89 crossed dipole receiving antennas designed to operate at 2 and 6 MHz. This, in effect, would be the world's largest low frequency radio telescope, designed to examine the lower ionosphere in detail.

Basil obtained funding for the project from the USAFOSR, the Australian Research Grants Committee, the Radio Research Board of Australia and the University. In 1965 construction of the array began on land the University had acquired from Buckland Park, a grazing property 40 km north of Adelaide. Honours and postgraduate students became riggers and trench diggers, suspending antennas and burying about 70 km of carefully measured cables that ran from each antenna to its receiver in the central laboratory. The array was completed in 1967 and the first observations of horizontal motion in the D-region of the ionosphere were made.

In 1969 the first publication arising from operation of the Buckland Array appeared in *Nature* with examples of a visual display of the outputs from the 89 receivers showing the drift of the diffraction pattern from ionospheric irregularities across the array. Accurate drift velocities were obtained by numerical correlation of the images. This unique instrument allowed more accurate determination of ionospheric drift velocities than had previously been possible. The first PhDs from this project were awarded to David Felgate and Dean Rossiter in 1970. David had made a direct verification of the point source effect, showing that the velocity of the ionospheric wind is half that of the diffraction pattern across the ground.

In the early 1970s an interesting device was built to convert the image of the diffraction pattern produced by the receiver outputs to a real image of the drifting ionospheric irregularities. It was an ultrasonic image former, effectively an analogue computer for two dimensional Fourier transforms. It consisted of an array of transducers on the surface of a sphere at the top of a cylindrical water-filled tank and a similar array at the bottom to convert the acoustic signals into voltages. Unfortunately the system could not be made sensitive enough and it was difficult to maintain. More recently, digital techniques have been introduced to increase the sensitivity and flexibility of the Buckland Park Array.

In 1968, Basil was joined by Paul Dennison, a Cambridge graduate who had been appointed to a lectureship. Paul, set about installing receiving arrays at Buckland Park, Burra and Kadina, forming a triangle with sides of approximately 150km. They were intended to observe the scintillation of radio signals from astronomical sources. However, the logistics of the project were too demanding and it was abandoned. During his time in Adelaide, Paul undertook scintillation observations using similar receivers he had built in Cambridge and equipment at the CSIRO radio-heliograph facility at Culgoora in New South Wales.

As more publications were produced on the basis of work with the Buckland Park Array, it was common that Basil selflessly promoted the interests of his students by not including himself as a co-author. It is said that when he prepared his own research papers he would compose, correct and edit them in his head and only when ready for publication would he write them down. This may be somewhat apocryphal, but Basil was a brilliant scholar of quiet disposition who had a remarkable ability to find the words that make a complex argument seem simple. This made him an outstanding lecturer. His neat blackboard work and his ability to produce a near perfect circle were legendary. Basil's mentor, Jack Ratcliffe, said of him shortly after he had left Cambridge for Adelaide: "Basil

Briggs is, I think, the soundest physicist I know.” A letter Basil wrote to Ratcliffe in 1981 is addressed ‘Dear Mr Ratcliffe’ and makes it clear that the respect was mutual. For twenty five years Basil was a member of the Editorial Advisory Board of the Journal of Atmospheric and Terrestrial Physics. He retired in 1984 and in 1992 was awarded the Harrie Massey Prize by The Institute of Physics. He died in 1994.

Radar and lidar

The meteor radar work begun by Graham Elford in the early 1950s continued strongly through the 1960s. A field station was established at St Kilda, about 20 km north of Adelaide. For his PhD, Carl Nilsson made measurements of over 2000 meteor orbits at St Kilda using a labour intensive electro-mechanical recording system. At the same time, Bob Roper investigated atmospheric turbulence using data for the drift of meteor trails. Carl and Bob were well known as a pair remembered for their exploits that included holding up a train when their car became stuck on a railway line.

In 1969, meteor observations using the Buckland Park Array were begun. Because the Array operated at a lower frequency than the meteor radars, trails could be observed at higher altitude. It soon became clear for the first time that the majority of meteor trails are to be found at altitudes inaccessible to most meteor radars.

In 1963 Graham Elford began a new initiative. He obtained funding from WRE for the design and construction of a lidar system with which it was hoped to observe scattering from meteoric dust at an altitude of about 100 km. This was just three years after the first practical laser had been demonstrated. In 1964 he took study leave and went to the Smithsonian Astrophysical Observatory in Boston. While there he met and had discussions with Professor Giorgio Fiocco of the Massachusetts Institute of Technology who had recently published lidar data that he interpreted as scattering by meteoric dust at 120 km. Graham discovered a small Boston company that had begun to manufacture lasers. On the basis of his discussion with them Graham commissioned them to supply a lidar transmitter based on their ruby laser that was Q-switched with a rotating prism.

Two postgraduate students joined the project: Karel Bartusek at the end of 1963 and David Gambling in 1965. They proceeded to complete the lidar system with a 12-inch Newtonian telescope as the receiver. The laser proved to be a troublesome device and had to be run at reduced power to avoid damaging the surfaces of the Q-switching prism. However, by 1969 optical scattering was observed to an altitude of 60 km with an altitude resolution of about 1 km. The data indicated molecular scattering except for enhanced scattering by an aerosol layer at an altitude of about 18 km. They were the first lidar observations in the Southern hemisphere. The project continued until 1980 and was later succeeded by a new instrument designed by Fred Jacka, Director of the Mawson Institute for Antarctic Research.

Graham Elford continued his meteor work for many years. In the 1980s he consulted with the Defence Science and Technology Organisation, Salisbury (formerly WRE), about problems they were having with the development of their over-the-horizon radar, Jindalee. Graham recognised that they were detecting large numbers of meteor trails and the radar was subsequently used for study of meteor trails. Graham never seemed to exhaust the possibilities for innovation in the analysis of meteor observations. It was after his retirement at the end of 1988 that he pioneered the measurement of meteor speed using radio phase techniques and radio holography. He was

recognised internationally, acting as President of the International Astronomical Union Commission on Interplanetary Dust and having an asteroid named after him (Elford 4974). Graham served the University in many ways. For six years he was Chairman of the Department of Physics and for many more years he gave valued counsel to others.

A second chair of Physics

Two particularly significant developments occurred in 1965: the appointment of Ken McCracken to a second chair in the Department of Physics and the arrival of Fred Jacka as Director of the Mawson Institute for Antarctic Research.

Ken McCracken was born in Queensland and graduated with a PhD from the University of Tasmania in 1959. He had built a network of neutron detectors that he operated during and after the International Geophysical Year. His field stations ranged from Mount Wellington in Tasmania to the Mawson and Casey Bases in Antarctica, and Lae in New Guinea. He wrote a thesis on variations in the cosmic ray intensity and then went to a postdoctoral position in Bruno Rossi's cosmic ray group at the Massachusetts Institute of Technology.

Bruno Rossi was a world leader in cosmic ray research and later established the field of X-ray astronomy. He was, perhaps more importantly for Ken, a superb mentor of emerging young scientists. Throughout his career Ken was to be grateful for Rossi's role in his maturing as a research physicist.

Ken went to MIT at a time when the US Government was pouring money into space research in response to the launching of the Sputniks by the Soviet Union. He discovered that building research satellites was not beyond a graduate of Australia's smallest university and this was an important lesson. His main achievement there was to undertake computations of the motion of relativistic charged particles through a high order simulation of the Earth's magnetic field. At the time there was no direct information about interplanetary space but there were several competing theories. When some strong solar flares occurred, Ken's calculations of the direction from which charged particles would reach the Earth from such events were found to be consistent with the solar wind model of interplanetary space. This established Ken's reputation in the field.

Ken became a consultant to the NASA Goddard Space Flight Centre in 1961 and then took up a position as Assistant Professor at the Massachusetts Institute of Technology. In 1962 he was appointed as a Professor at the Southwest Center for Advanced Studies of the University of Texas. There he became a Principal Investigator for seven NASA Pioneer and Explorer spacecraft for which he designed and built instruments to study cosmic radiation. Some of these spacecraft were not launched until after Ken had arrived in Adelaide.

While at the University of Texas, Ken began work in X-ray astronomy. This field of research had its origin in 1962 when Bruno Rossi used rocket-borne detectors to make the first discovery of an extra-solar X-ray source, Scorpius X-1. Ken and George Clark, a colleague from MIT, then figured out independently that a balloon-borne detector could be used to look for the high energy, more penetrating, end of the X-ray spectrum. Clark built a balloon package and flew it from Texas in July 1964. He observed X-rays from the Crab Nebula. Ken had already built a balloon payload with cosmic ray experiments which he had flown from Fort Churchill in northern Canada and he was

about to take it to India. He hurriedly built an X-ray telescope and added it to the payload. It was flown from Hyderabad in India in March/April 1965 as part of the joint US-India International Quiet Sun Year Equatorial Expedition. At the first launch the balloon had insufficient buoyancy and the instrument package came to rest in the University Botanical Garden, half a mile from the launch site, suspended 10 feet above the ground in an Australian wattle tree. However, there were other successful flights that took his instruments to float at a height of some 38 km for several hours. His data revealed the new X-ray source Cygnus-XR1. Later in the year Ken brought the payload to Australia intending to scan the Large and Small Magellanic Clouds. It was launched from Waikerie. According to Ken 'it was 2 am, it was very cold and the balloon failed'.

When he was appointed as Professor of Experimental Physics in Adelaide, Ken retained his role as a NASA "Principal Investigator" and continued to analyse some of his satellite data in conjunction with colleagues still at Dallas. He arrived in Adelaide in September 1966 and established a Cosmic Ray Laboratory in which three distinct research areas emerged: cosmic ray research, X-ray astronomy using balloons and X-ray astronomy using rocket-borne detectors. Two of the Department's staff who were already working with X-ray detectors became his colleagues. They were Alan Gregory and Paul Edwards. Ken had known Paul in Tasmania and at the Southwest Center for Advanced Studies, Texas, when Paul took leave from the University of Adelaide in 1965.

The cosmic ray research continued Ken's interest in the propagation of cosmic rays through the interplanetary medium and the dynamics of the solar wind. Data flowed from Ken's satellite experiments. It was couriered to Australia in a diplomatic bag to be analysed with the University's computer. Ken made annual trips to Dallas to write papers with his colleagues there. In Adelaide, graduate students performed calculations of cosmic ray propagation and compared model calculations with Ken's satellite data. Leighton Barnden used computational tracing of the paths of cosmic ray particles and other tools to study the variations in the cosmic radiation observed at Earth. Ian Urch, working with Leo Gleeson at Monash University, also investigated the modulation of cosmic rays and parameterised a "modulation potential" which is still in use 40 years later to quantify the day-to-day radiation risk for airline passengers, astronauts, satellites, and other technological infrastructure. Ian Palmer conducted a comprehensive study of the manner in which solar flares and coronal mass ejections accelerate cosmic rays with serious consequences here on Earth. Barnden, Palmer and Urch all completed their PhDs after Ken McCracken had left Adelaide. Collectively they produced many publications on their work and they went to post-doctoral appointments around the world

Late in 1966 Ken flew his balloon payload from Mildura as a 'hitch hike' on an MIT balloon. The balloon was launched from the facility maintained by the Department of Supply at Mildura. The facility was used primarily by the US Project Ashcan in which nuclear air sampling was undertaken to detect fallout from nuclear weapons tests by the Soviet Union. Balloon launches were early morning events to avoid windy conditions, but subject to sudden cancellation because of adverse weather. Filling the balloon with helium was a slow process and the expense was such that it was undertaken only when there was confidence in the continued suitability of the conditions.

A new balloon package was then developed in Ken's laboratory. This X-ray observatory was flown for the first time on 19 February 1968. It had two independent X-ray detectors, differing in the shielding used to define the detector field of view. Both featured anticoincidence detectors to

discriminate against the background signal produced by Compton scattering of X-rays and Y-rays in the collimator. In one the detector, a caesium iodide crystal, was surrounded by a graded shield consisting of layers of metals (lead, silver and copper) arranged according to atomic number with the highest on the outside and an inner layer of plastic scintillator as an anti-coincidence detector. The other used a totally active collimator in which the detecting crystal was at the bottom of a thick well of scintillating material that provided an anticoincidence signal. The packages were developed by three postgraduate students: the graded shield detector by Gioachino (Jock) Buselli, the actively shielded detector by Michael Clancy and the telemetry system by Richard Thomas. The observatory was flown on a 10 million cubic foot balloon, the largest then available. The pointing direction of the telescopes was controlled by radio to scan the celestial objects of interest. During the flight, data about the spectral properties of three X-ray objects, GX 3+1, GX 354-5 and Sco XR-1 were recorded. Data were also obtained for a number of other weaker sources. This flight led to a series of widely cited publications and was a significant contribution to X-ray astronomy.

In all there was a series of six balloon flights in the period 1968-70, two of which were aborted early so that no useful data was recorded. These flights produced ground-breaking data for the strength, spectrum and variability of X-ray emissions from stellar sources in the southern sky. It was found that the X-ray spectrum was sometimes best described by a power law and sometimes it had an exponential form, implying different emission processes in the source object.

Like John Carver, Ken saw the opportunity to use rockets launched from Woomera to carry instruments to high altitude. The British Skylark rockets were ideal because they attained an altitude sufficient for the observation of the whole X-ray spectrum. Carver had already sounded out the possibility of gaining access to Skylark rockets launched from Woomera. In 1964, after talking to Harrie Massey, an Australian who chaired the British National Committee on Space Research, he had visited the home of the Skylark project at the Royal Aircraft Establishment, Farnborough. His talks were inconclusive but encouraging. Later, when Ken and Geoffrey Fenton, his PhD supervisor from Tasmania, were in London they visited the UK Science Research Council in London and persuaded them to make space available on Skylark rockets. They would have two flights, not as an Australian project but as part of the British space program at Woomera.

The Skylark flights took place in April 1967. They carried X-ray detectors that were built as a project of the Universities of Adelaide and Tasmania, a collaboration known as UAT. The detectors were gas-filled proportional counters based on a design developed by the Tasmanian group, Geoffrey Fenton and his student Roger Francey. The proportional counters had the advantages that they could be made with a window area large enough to detect faint stellar X-ray sources and they also provided energy discrimination that enabled the X-ray energy spectrum to be determined. John Harries was the first Adelaide postgraduate student to engage in this work.

These two flights led to the discovery of a new source in the constellation of Crux, now known as Centaurus XR-2, and demonstrated for the first time that the intensity of stellar X-ray sources can change rapidly with time. When Ken presented this result at a conference in the United States it was greeted with disbelief by theorists, but the phenomenon was soon firmly established.

Following these flights the rocket-borne X-ray work developed a life of its own. After completing his PhD, John Harries obtained a Queen Elizabeth II Fellowship and continued rocket X-ray work until he left in 1970 to take up an appointment at the Australian Atomic Energy Commission Research Establishment in NSW. Roger Francey in Hobart also continued to play a leading role in the work. In all there were seven UAT flights in the period 1967 to 1970 and except for the two initial flights they were arranged as Australian projects. With each flight the total collecting area of the detectors was increased. The flights were successful, except that UAT Flight IV had an unsuccessful launch and UAT Flight VII, on an American Aerobee rocket, failed because the hatch covering the UAT detectors separated prematurely and destroyed the proportional counter window. Several new sources were discovered and other known sources observed. Observations were also made of the diffuse X-ray flux, including the terrestrial X-ray albedo. Ian Tuohy was the last of the ray astronomy post-graduates to complete his thesis. He was involved in four rocket flights in the period 1969-70, two of which were successful. UAT Flight VI, in July 1970, was particularly successful and the data formed the basis of Ian's PhD thesis in which he reported observations of the Crab Nebula, the galactic source Norma X-2 and the Large Magellanic Cloud. He confirmed that the Large Magellanic Cloud has at least two X-ray emitting regions. The data provided the first evidence for the disappearance of the intense source Cetus X-2, showing that it is a flare star. Ian went to a post-doctoral appointment in the Mullard Space Science Laboratory at University College, London. Later he had an appointment at the ANU where he continued to work on X-ray astronomy using data from a NASA satellite. More recently he has worked for an aerospace company in Adelaide.

Another of Ken postgraduate students undertook pioneering investigations in radio astronomy. Jack Gubbay graduated with Honours in Physics from the University of Western Australia in 1950 and in 1955 he joined WRE, Salisbury. In 1964 a Space Research Group was formed within the American Projects Division of WRE with a view to utilising NASA facilities based in Australia. Three physicists were appointed to the group: Dave Robinson as leader, Jack Gubbay and Anthony Legg. Jack read papers by groups from the University of Manchester and the Royal Radar Establishment, Malvern, reporting long baseline interferometer observations of quasars using radio telescopes at Jodrell Bank and Malvern. The antenna dishes were separated by some 130 km and a microwave link allowed the signals to be combined. Jack realised that the rubidium frequency standards installed at the NASA Deep Space Stations in Australia would allow combination of the signals without a direct communication link so that there was no restriction on the separation of the stations. A proposal was developed to test very long baseline interferometry using radio telescopes at Island Lagoon, south of Woomera in South Australia, and Tidbinbilla near Canberra. This gave a baseline of some 1,200 km. Initial results were reported in September 1967, with the suggestion that the experiment opened the way for using Deep Space Stations on different continents, giving another order of magnitude improvement in resolution.

Arrangements were then made to set up an interferometer operating between Australia and California with a baseline greater than 10,000 km giving an angular resolving power of about 10^{-3} s of arc. Initial results were reported in September 1969 and by December they reported the first observation of superluminal expansion of the radio structure associated with a very distant quasar. Expansion at an apparent velocity greater than the speed of light, the result of relativistic expansion at a small angle to the observer, had been predicted by the British cosmologist Martin Rees. The observation of the effect removed some objections then being raised to the Big Bang model of the universe.

In 1967 Jack Gubbay enrolled as a postgraduate student at the University of Adelaide. The intercontinental VLBI experiment was his project and data from the project were processed with the University's CDC 6400 computer. Jack chose Ken McCracken as his supervisor and found that Ken's preparedness to 'ask the stupid questions' and his insistence on coherent data reduction greatly assisted the project. Jack's co-supervisor was his team leader, Dave Robertson, who had obtained a PhD from the University working on meteor radar observations with Graham Elford. The international team that worked on the project included Ron Ekers who had been in the 1962 Honours class in Adelaide and was then at the Owens Valley Radio Observatory of the California Institute of Technology.

Ken left Adelaide at the end of 1969. He went to the CSIRO as Officer-in-Charge of the Mineral Physics Section and then as Foundation Chief of the Division of Mineral Physics. In 1989 Ken left the CSIRO and with his wife Gillian founded Jellore Technologies, a company consulting to the mining industry. (Ken lives adjacent to the Jellore State Forest in the Southern Highlands of NSW.) Later he developed an interest in palaeo-cosmic rays, began collaborating with scientists at the University of Maryland, USA, and became a Senior Research Associate there. Recently, with colleagues from Maryland and the Swiss Federal Institute of Aquatic Science and Technology, he used ^{10}Be data from ice cores and ^{14}C data from tree rings to deduce the level of solar heliospheric activity over the past 9,300 years. More recently, Ken and his colleagues have demonstrated a correlation between these data and the planetary torque on the sun, controversially reviving an old hypothesis about planetary influence on solar activity.

Ken had a considerable impact on the Department. His impatient energy was a driving force and he maintained a wide range of interests and connections. His international contacts enhanced the external focus of the Department. Nine PhDs came from his laboratory. Peter van Rood, the Executive Officer of the Department, was once heard to remark about Ken that he 'piles more onto his fork than anyone I have ever met'. He was a practical person who was always a hands-on experimental physicist. He was thoroughly familiar with his balloon payload instrumentation and would make the repairs to the electronics himself if there was damage from a rough balloon landing.

Ken's work has been recognised with many awards. He was made a Fellow of the Australian Academy of Science, the Australian Academy of Technological Science and Engineering, and the International Academy of Astronautics. He received the Australian Academy of Science Pawsey Medal (1969), the Australian Society of Exploration Geophysicists Gold Medal (1989), a DSc Honoris Causa from the University of Tasmania (1990), the Australia prize (1995), the Centenary Medal (2001), the Australian Academy of Science Ian Wark Medal (2001) and the Australian Academy of Science Haddon King Medal (2003). In 1989 he was made an Officer in the Order of Australia.

Paul Edwards left Adelaide at the end of 1967 to take up an appointment at the University of Dunedin in New Zealand and was later at the Canberra CAE/University of Canberra. The chair vacated by McCracken was filled in 1971 by the appointment of John Prescott who had been a member of the 1944 Honours class and came to the University from an appointment at the University of Calgary in Canada. John's research field was the observation of cosmic ray induced air-showers and in Adelaide he established an array of detectors at the Buckland Park Field Station. Roger Clay, who had just taken up a postdoctoral position with Prescott at Calgary, came with him to

Adelaide. Roger's PhD was from Imperial College, London, on extensive air-showers. Other foundation members of the new Cosmic Ray Research Group were Alan Gregory and John Patterson who had been appointed to a lectureship in 1968. John was an Adelaide Honours graduate, had a PhD in nuclear physics from ANU and came from postdoctoral work at the California Institute of Technology.

The Mawson Institute for Antarctic Research

In 1959 the University of Adelaide established the Mawson Institute for Antarctic Research. Its purpose was to commemorate and honour the work of one of its most distinguished members, Sir Douglas Mawson, by fostering polar studies and research. The University's vision was that it would maintain a library of papers, maps and books on Antarctica; it would include a museum containing a reference collection of geological and biological materials from the Antarctic as well as materials and equipment associated with Antarctic exploration; and it would stimulate interest in the Antarctic with public lectures. It was intended that the Institute would be accommodated in a major new annex to the Geology Building and provide facilities for research in Antarctic matters.

A Committee of Management was established and on 15 April 1961 the Institute was inaugurated by the Prime Minister, the Rt Hon RG Menzies. It was a grand occasion with representatives from the Royal Society, the USSR Academy of Science, the Australian Academy of Science, the Royal Geographic Society, the Argentina Institute of Antarctic Affairs and the Scott Polar Research Institute. In 1962 the book *The winning of Australian Antarctica : Mawson's B.A.N.Z.A.R.E. voyages, 1929-31*, based on the papers of Douglas Mawson and written by A Grenfell Price, was published for the Mawson Institute for Antarctic Research. This was the first publication of the Institute.

Then the University advertised for a permanent Director of the Institute and in June 1964 Dr Fred Jacka, an auroral physicist, was appointed. This appointment had a profound impact on the way the Institute developed, moving its emphasis away from geology to atmospheric physics.

Fred Jacka grew up in the small western Victorian town of Ouyen, studied physics at the University of Melbourne and graduated in 1947. He joined the newly formed Antarctic Division of the Australian Department of External Affairs, then based in Melbourne, and wintered on Heard Island in 1948. There he made observations of cosmic rays and magnetic disturbances. Then he made a computational analysis of auroral data collected in the Antarctic by scientists of the Antarctic Division. In 1955 he was awarded a PhD by the University of Melbourne for a thesis about the causes of variation in cosmic ray intensity and the relation of the aurora to geomagnetic disturbances. For the remainder of the 1950s Fred focused on identifying the geographic distribution of auroras in the southern hemisphere. His series of papers on the location of the auroral zone was a major achievement. During this time he rose through the ranks to become Assistant Director (Scientific) of the Antarctic Division.

In 1964 Fred applied for the position of Director of the Mawson Institute for Antarctic Research and in June he was offered the position. He discussed the offer with his boss Phillip Law, Director of the Antarctic Division, and was encouraged about the prospect of the Institute receiving support from the Division to develop an Antarctic research program. So he accepted the position, agreeing to take it up in June 1965. His intention was to develop a multidisciplinary research institute and he expected substantial support from the Antarctic Division and the University of Adelaide. Excited by

his vision for the Institute, he set about winding up his work at the Division and began considering the projects he would pursue in his new Institute.

According to Tim Bowden, in his book *The Silence Calling: Australians in Antarctica 1947-1997*, Fred had proposed that the Institute take over responsibility for some research programs of the Division, but the Division was not willing to relinquish them. In discussions between the Division, the University of Adelaide and Dr Jacka it became clear that the University was not keen to take on responsibility for funding them, but it was agreed that the Institute could have a significant role in oceanography, marine biology, and 'certain aspects of upper atmosphere physics'.

It was only after he arrived in Adelaide in June 1965 that Fred realised how little funding he would receive. Phillip Law was at that time considering his own retirement and was preoccupied with securing future Government support for the Division. He was unable to support the Institute with anything more than logistical support to undertake research in the Antarctic. An oceanography program was proposed for the 1965-66 season with Law's encouragement, but neither the Government nor the University would provide the modest funding required and the project was never undertaken. There was a perception in the Government that the Institute was little more than a Director and a name. There was also a concern about the apparent reluctance of the University to provide it with any significant funding. Fred discovered that although his new appointment was at the level of professor he was not to receive the level of support expected by a university professor.

However, the University did gradually release some funding for positions in the Institute. In 1966 the Institute was able to appoint a secretary and a technical officer and in 1967 he appointed Don Creighton, an engineer. Don had worked for the Postmaster General's Department in Melbourne, and in 1963 Fred appointed him to winter at Mawson Base, operating and maintaining scientific equipment. Fred believed that appointing an engineer rather than an additional scientist was the best way to add new skills to the expedition. The success of this arrangement was such that when Fred had funding to make an academic appointment he opted to appoint Don rather than a physicist. This proved to be an insightful choice and over more than 20 years Fred and Don combined their skills to produce the innovative instruments that characterised Fred's research program.

Following his arrival in Adelaide, Fred pursued his interest in atmospheric physics with modest funding from the Australian Radio Research Board and the Australian Research Grants Scheme together with often uncertain logistical assistance from the Antarctic Division. He mounted a program of measurements of auroral and airglow phenomena. The Institute acquired a field station at Mount Torrens in the Adelaide Hills and it was used to test new equipment, train postgraduate students and to undertake important mid-latitude observations of atmospheric emissions that complemented the Antarctic observations. He began to attract postgraduate students. Two former Antarctic Division scientists completed MSc projects with him and by the end of 1970 two PhDs had been completed.

In 1967 the Institute formed a biology group under the leadership of Robert Carrick to engage in ecological studies of birds and seals. It was accommodated in various University departments until the whole of the Institute moved into the newly completed first stage of the Physics Annex in 1968. On the retirement of Carrick in 1971 the biology group was disbanded.

In 1969 Fred was offered another academic position and the University persuaded him to accept the transfer of Pat Seymour, a theoretical physicist engaged in studies of plasma dynamics in the Department of Mathematical Physics. It was planned that Seymour would undertake work on the dynamics of the upper atmosphere, but this did not occur and he resigned in 1977. The position was not released for further appointment.

In accord with the original vision, the Institute did maintain a small library and museum. It included books by and about Mawson, Mawson's correspondence relating to Antarctic work, equipment from Mawson's Antarctic expeditions and Antarctic photographs. Included in the photographic collection were some stunning photographs by Frank Hurley who accompanied Mawson on his 1911-14 expedition. In 1988 the Institute published the book *Mawson's Antarctic Diaries* that had been edited and annotated by Fred and his wife, Eleanor Jacka.

Fred's research interest was the structure and dynamics of the upper atmosphere at high latitudes. He used remote sensing techniques to determine wind speeds, temperatures and gravity wave characteristics. Most notable of the instruments that he developed were a large aperture high resolution scanning Fabry-Perot interferometer and a Doppler lidar. The interferometer was used to observe airglow emissions from a well-defined altitude to determine atmospheric winds and temperatures by measuring the Doppler shift and Doppler broadening of a spectral line respectively. The lidar was unique in using the same one metre telescope for both transmission of the outgoing laser pulse and reception of the incoming backscattered light. In its Doppler form, the instrument had a dual etalon Fabry-Perot spectrometer to measure the line of sight wind. Both instruments were considerable feats of design and engineering.

In the 1980s Fred participated in research of a quite different nature with characteristic energy and commitment. Ian Forbes of the University's Department of Medicine came to the Department of Physics and explained that he planned to undertake a cancer therapy project. It involved the injection of a drug that is selectively retained by cancerous tissue and becomes toxic on exposure to light. He needed a bright red light of the colour most readily transmitted by human tissue. He had no budget and hoped that the Physics Department could provide a suitable lamp. The challenge was taken on by Fred and Alastair Blake and, with generous assistance from WRE, a somewhat crude lamp was built and used successfully in the treatment of skin cancers. A grant was then obtained that made possible the construction of a more sophisticated lamp that was used in conjunction with surgery for the phototherapy treatment of brain tumours with encouraging results. However, a problem with residual photosensitivity in the patients and difficulty of obtaining access to suitable patients brought the project to an end.

When Fred retired in 1990 the Mawson Institute for Antarctic Research was closed and Don Creighton was relocated to a position in the Faculty of Science. The Institute had been an episode in the history of the University of Adelaide that had taken a surprising turn to atmospheric physics so that it was both a disappointment and a triumph. Many of the original aspirations for it were never realised for lack of funding, but the achievements of Fred, Don, their technical staff and students were impressive. Fred Jacka was a meticulous experimentalist who had a genius for conceiving of instruments that no-one had ever built, to make measurements that no-one had ever made. His love of innovative technology was reflected in his choice of car – a Citroën DS that he drove for many

years. Don's engineering skills complemented Fred's in a creative way. Fred supervised 24 MSc and PhD projects and he published some 50 scientific papers based on the work of the Institute. Fred was a wonderful colleague. Those who wrote papers with him quickly learnt that only as a last resort should a comma be used to punctuate the text. He was single-minded in pursuit of his objectives but always supportive of colleagues and students. He strove for excellence in everything he did and would sometimes frustrate colleagues by abandoning an almost implemented idea if a better one emerged.

Fred made numerous contributions to the University in addition to his work with the Institute. He contributed to the teaching of the Department of Physics, lecturing to first and third year classes. At his suggestion Don Creighton devised and presented an innovative course in digital electronics to the Department's Honours classes. Fred served on a number of University committees and on national and international professional committees. He made written and verbal submissions to Senate Committees on Antarctic matters. All of these things he did with his characteristic goodwill, attention to detail and striving for excellence.

Twice during the 1970s Fred took extended leave because of serious illness. He died in 1992. In his eulogy, Keith Cole paid tribute to Fred's courage in coping with illness and observed that he will be remembered most of all as a person with a 'great zest for life, a fine sense of humour, and an aversion to nonsense and humbug.'

Physics at Flinders

In 1964 an appointment was made that began a new chapter in the story of physics in Adelaide. Max Brennan was appointed as Foundation Professor of Physics for a new campus of the University of Adelaide which was to be located on a hilly site at Bedford Park. At the time of his appointment the new campus was not ready and Max moved into the Physics Department at North Terrace.

Max Brennan graduated from the University of Sydney with Honours in physics in 1954 and a PhD on cosmic ray air showers in 1958. He then had a three year postdoctoral appointment at Princeton University working on low energy nuclear physics. As time went on, Max thought about the lectureship that Harry Messel had invited him to take up at the University of Sydney. He decided that rather than return to cosmic ray work he would join the plasma physics group being set up in Sydney by Charles Watson-Munro. With this in mind Max spent his last year at Princeton in the plasma physics laboratory. When Max returned to Sydney early in 1961, Watson-Munro had just returned from a year at Berkley engaged in plasma physics research. Together, Charles and Max pursued the approach they had discussed when Charles visited Princeton – to build linear plasma sources that used a hydromagnetic ionising shock wave to produce highly ionised plasma at low cost.

When Max arrived in Adelaide, there were many tasks demanding his attention. Peter Karmel, Professor of Economics at the University of Adelaide, had been appointed as Principal Designate of the University of Adelaide at Bedford Park. Peter had obtained an agreement from the University Council that the new campus would be academically autonomous and that he would be responsible for academic planning. It had been decided that there would be a school rather than a faculty structure and Max was designated Head of the School of Physical Sciences.

The first physics staff appointed to the new School were John Fletcher and Robin Storer. John had a PhD on the ionization coefficients of gases from Keele University in Staffordshire and in 1963 went to the University of New England where he was a Senior Demonstrator and worked on electron swarm research with Harry Blevin. Robin was in the 1959 Honours class in mathematical physics at Adelaide and his PhD on the statistical thermodynamics of irreversible processes was supervised by Bert Green. He went to a postdoctoral appointment with Harold Grad in the Courant Institute of Mathematical Sciences at New York University. There he developed his interest in statistical mechanics and was immersed in theoretical research in plasma physics. When it was time to find a further position Robin wrote to Max Brennan who interviewed him during a visit to the United States; Robin was appointed as a theorist to the plasma physics group and arrived in Adelaide in October 1964.

A course structure had to be designed and after reviewing universities around the world Max and his School staff decided on a set of degree programs that took advantage of synergies between the disciplines of the School. In each program a set of unit topics was specified. Max asked Robin Storer to develop the first year lectures. In order to make the course attractive to students it was decided that emphasis would be placed on relating each topic to contemporary research. At this time the innovative *Berkley Physics Course* had just become available and it was used as the text. Use was also made of the challenging *Feynman Lectures in Physics*. John Fletcher set about developing a first year laboratory in which students were encouraged to treat the experiments as small research projects rather than as traditional demonstrations of lecture material and were required to write an end of term report. There were three sets experiments – dynamics, waves and oscillations, and quantum mechanics.

Then there were the buildings for the new campus which, when Max arrived in Adelaide, had been designed but not built. He reviewed the plans for the Physical Sciences Building and made revisions, particularly to the design of the research laboratories.

Finally, Max began the construction of equipment for his research. With the assistance of his first postgraduate student, Trevor Blackburn, and the Adelaide workshop he set about building a plasma source similar to the one he had used in Sydney.

At the beginning of January 1966 Max and his staff moved to the Bedford Park campus. The buildings were barely ready for occupation, but they immediately went to the first year laboratories and began setting up their new equipment ready for the first intake of students who would arrive at the beginning of the academic year. The University of Adelaide Council had agreed that while students would be asked to choose between the North Terrace and Bedford Park campuses, offers of places would be made in such a way that the average intake score would be the same for both campuses. At that time the Bedford Park campus suffered from the lack of an established reputation and from a lack of access by public transport. This meant that some students had to be directed contrary to their preference. In March classes began at Bedford Park with a staff of 90 and 400 students.

During 1965 there was much political discussion about the status of the Bedford Park campus. Both of the major parties had as a policy the establishment of a second university in South Australia. The

Labor Government favoured establishing the Bedford Park campus as an independent university to be named 'The University of South Australia'. As the idea of a new university at Bedford Park began to take hold, Peter Karmel and his campus planning group urged that the name be made distinctive by adding 'Flinders' in commemoration of the famous explorer. By the end of 1965 political agreement on a new university had been reached but it was not until March 1966, just over a week before the Bedford Park campus was to be formally opened by Her Majesty Queen Elizabeth, the Queen Mother, that the State Parliament passed the Flinders University of South Australia Act.

At the new campus, Max Brennan established his plasma physics research program. He used an ionising shock wave to produce a plasma column and studied optimum configurations for the formation of highly ionized plasmas, developed plasma diagnostic methods, and undertook a study of the propagation of Alfvén waves in the plasma including the possibility of heating effects for waves near the ion cyclotron frequency.

Further appointments were made of experimental physicists in the general area of plasma physics. Eric Murray was seconded from the Adelaide Department and moved to Flinders at the beginning of 1966. William (Bill) Westwood also came to Flinders early in 1966. He had a PhD from the University of Aberdeen, Scotland, on the optical absorption spectra of doped crystals. In 1962 he went to the Northern Electric Research and Development Laboratories in Ottawa, Canada, and worked on ferrite films. At Flinders he applied his expertise in optical spectroscopy to the study of plasmas. After three years at Flinders he returned to Northern Electric R&D. Harry Blevin took up an appointment as Senior Lecturer in 1967. He undertook a PhD at the University of New England on the effects of magnetic fields on gas discharges and then went to a postdoctoral appointment at the Atomic Energy Research Establishment at Harwell before returning to UNE as a Lecturer. Lance McCarthy was appointed to a lectureship in 1968. He graduated from the University of Auckland and had an MSc from there. He also had a PhD in experimental nuclear physics from the University of Pittsburgh. In 1969 Malvern (Mal) Phillips was appointed. He had a PhD from the University of British Columbia, Canada, on the production of hypersonic shock waves in an electrothermal diaphragm shock tube.

There was now a considerable plasma physics group and Flinders developed a reputation for this work. Max kept a close interest in the work, but his administrative work as Head of School often kept him out of the laboratory. His astute work in persuading the University to make funding available for new appointments was critical to the growth and success of the School.

Several years later the appointment of Ieuan Jones led to a new phase in plasma physics research at Flinders. Ieuan was raised in Pwllheli, a seaside market town in North Wales, and graduated with a PhD from the University College of Wales at Aberystwyth. He went to a postdoctoral appointment at the California Institute of Technology and in 1960 he moved to the Aerospace Corporation in Los Angeles where he began research in the fields of plasma physics and nuclear fusion. From there he went to the Swiss National Plasma Physics Laboratory in Lausanne. He was appointed as a Senior Lecturer at Flinders University in 1972 and quickly made a mark as a gifted lecturer. His lectures on electromagnetism in particular were noted for their concision and clarity, but it is for his plasma physics research using a rotating magnetic field in a plasma containment device that he is especially remembered.

The idea of using a rotating magnetic field in a plasma containment device had originated earlier. When Harry Blevin went to Harwell in September 1958 he worked with Peter Thonemann. Peter was an Australian who led the Zeta nuclear fusion project which had recently been in the headlines because it was (falsely) thought to have achieved nuclear fusion. Harry was given a choice of projects and opted for one that concerned an idea Thonemann had about rotating magnetic fields. He had done an experiment in which a travelling magnetic field carried electrons around a torus. He wanted to try a magnetic field that rotated at MHz frequency around the axis of a cylindrical plasma column. The idea was that when a transverse rotating magnetic field penetrates a cylindrical plasma column, the electrons would be tied to the rotating field lines while the ions would have no net azimuthal motion. The electrons would form a steady azimuthal current that maintains the ionisation while an applied axial magnetic field would contain the plasma. Harry did some calculations and performed some successful experiments. In 1961 Harry returned to UNE where he did some further experiments with rotating magnetic fields and resumed his work on electron swarms. When he was offered a senior lectureship at Flinders University, he had been about to take study leave at the Culham Laboratory of the UK Atomic Energy Authority where Thonemann was then working. Harry negotiated an agreement with Flinders that he could take study leave in 1968, a year after he arrived at Flinders. While he was at Culham, Ieuan Jones visited. Ieuan was then working in Lausanne and had heard about Harry's experiments with rotating magnetic fields. He was interested in the idea.

Meanwhile, Robin Storer's main research interest after arriving at Flinders had been in quantum statistical mechanics. At New York University he gained experience using large computers and at Flinders he undertook computational work applying Monte Carlo techniques to quantum statistical mechanics. But by 1973 he was looking to change his focus toward work more closely related to plasma physics. He took study leave at a plasma physics laboratory in Utrecht, Holland, and did theoretical work on plasma equilibrium in tokamak plasma containment devices.

At Flinders, Ieuan Jones became involved in the work of the Plasma Physics group, but he also became interested in work done at the Princeton Plasma Physics Laboratory on a low aspect tokamak that they called a spheromak. In 1977 he made a small device that combined a rotating field and a spherical configuration. Robin Storer undertook theoretical work associated with this configuration. In February 1979 Ieuan made a proposal in which he coined the term 'rotamak' for a device in which a toroidal plasma in a spherical chamber is driven by a rotating magnetic field and kept in equilibrium by an external axial magnetic field. By the addition of a steady toroidal magnetic field, the device becomes a spherical tokamak in which the plasma is maintained by the rotating field. He claimed that such a device had considerable advantage in plasma containment time.

Ieuan continued to experiment with his rotamak, constructing successive generations of improved devices, but it took time for the concept to attract interest beyond Flinders. In 1981 the Australian Nuclear Science and Technology Organisation (ANSTO) took up rotamak research with Ieuan as a consultant. When Ieuan retired in 2000, the Flinders rotamak was relocated to the Prairie View A&M University in Texas and there are now several universities around the world working with rotamaks. At one of them, the Kansai University in Japan, a rotamak is being used as a source of extreme ultraviolet radiation for application to photo-lithography. In recognition of his achievements in pioneering rotamak research, Ieuan was made a Fellow of both the American

Physical Society and the Institute of Physics. After retirement he spent each northern summer in Pwllheli, immersing himself in Welsh culture. He died there in 2011.

Despite his role in the origin of the rotating field concept, Harry Blevin did not become involved in the rotamak research, but continued highly productive work with electron swarms and with various phenomena occurring in gas discharges in magnetic fields. He was promoted to a newly established chair in 1969 and retired in 1989. Harry was a cricketer, played for Flinders and was noted as a hard-hitting batsman.

Max Brennan left Flinders earlier. In 1981 he resigned his position as Foundation Professor at Flinders. His role in guiding the School of Physical Sciences toward a secure future was complete. He moved back to Sydney as professor of Physics at the University of Sydney and later served that University as Pro-Vice Chancellor. He chaired the Australian Atomic Energy Commission, the Queen Elizabeth II Fellowships and Australian Research Grants Committee and then, in 1991, he took up a full time position as Chairman of the Australian Research Council. He was Chairman of the International Fusion Research Council. He was made an Officer in the Order of Australia in 1986, was elected a Fellow of the Australian Academy of Science in 1988, and was awarded the Centenary Medal in 2001. In 1997 Max retired and returned to live in Adelaide.

When he came to Flinders, Robin Storer had resumed contact with his thesis supervisor, Bert Green. He attended the Mathematical Physics seminars and sometimes the Mathematical Physics people would go to Flinders for a seminar. As the number of theoreticians at Flinders increased the joint seminar became a weekly event that alternated between the two campuses. There would be lunch at either the Marion Hotel or the Hackney Hotel with the seminar to follow. This tradition continued for many years.

Atomic Physics at Flinders

In 1967 the Flinders University Council approved the establishment of a Chair in Theoretical Physics. Max Brennan made a visit to Ian McCarthy at the University of Oregon to sound out his interest in joining the School at Flinders. With the understanding that further appointments would allow him to gather a group around him, Ian agreed and he took up the position at Flinders in 1968.

Ian saw the opportunity to act on his conversations with Erich Weigold about the $(e,2e)$ reaction and talked to Erich about joining him at Flinders. Erich, who now was Chief of the Nuclear Physics Division of the US Airforce Office of Scientific Research in Washington DC, in turn saw the opportunity to collaborate again with Peter Teubner who had been his student at the University of Adelaide. Consequently, Max interviewed both Erich and Peter. Erich was offered a senior lectureship at Flinders, accepted it and arrived in August 1970 after his contract with the AFOSR had ended.

As he was returning to Adelaide in 1968 Ian McCarthy visited Erich in Washington. They called Peter and encouraged him to apply for a position that Flinders had advertised. Peter applied, but the position was offered to Mal Phillips to work in the plasma physics group. Later, Ian called from Adelaide and encouraged him to apply for another position. Peter was offered this one and he returned to Adelaide in 1969.

After completing his PhD at Adelaide University, Peter had gone as a postdoctoral fellow to the University of Pittsburgh in 1967 to work with Professor Wade Fite. Fite had a large group of experimentalists and theoreticians and had made the first measurements of electron scattering from atomic hydrogen. Peter soon discovered that the measurements of the differential cross-section for the elastic scattering of electrons from hydrogen atoms that he had made in Adelaide and which he had not published were of great interest to the Pittsburgh theoreticians who had made calculations of the scattering. Together they quickly set about publishing a comparison of Peter's data and the calculations. At Pittsburgh Peter worked on several atomic scattering projects, affirming his reputation as an able experimentalist. Before leaving Pittsburgh, Peter made a successful application for an ARGC grant to undertake atomic hydrogen electron scattering measurements at Flinders. At Ian McCarthy's request, Peter travelled to Adelaide via Italy to visit the group of Ugo Amaldi in Rome. They had been the first to observe coincidences in an (e,2e) experiment.

Another position in Ian McCarthy's group was filled by Brian Davies, who had a PhD in theoretical nuclear physics from the University of New South Wales. He arrived in 1967 and collaborated with Robin Storer on topics in computational physics. Brian left at the end of 1969 and went to ANU. In 1970 the position was offered to Iraj Afnan and he arrived in August of that year.

Iraj graduated from the American University of Beirut, Lebanon, and then, in 1966, completed a PhD at the Massachusetts Institute of Technology on the shell model of nuclear reactions. He went to a postdoctoral appointment at the University of Minnesota. Later he was looking for a further postdoctoral position and he wrote to Ian McCarthy at the University of Oregon. Ian had been at Minnesota for a while in the 1950s and Iraj had seen Ian's recently published book *Introduction to Nuclear Theory*. Ian replied that he was leaving to take up his appointment at Flinders, but asked Iraj to contact him again if he was interested in going to Flinders. Iraj also contacted Lindsay Dodd at the University of California at Davis because he had seen Lindsay's publications on three body theory. Iraj was offered a position at Davis, but arrived just as Lindsay was leaving to take up his appointment in Adelaide. Although Iraj continued to work on the three body problem, it was never to be with Lindsay. It seemed, however, that Iraj was fated to move to South Australia. When he met Ian McCarthy at an American Physical Society meeting in Washington and Ian suggested that he apply for a Flinders lectureship that was being filled. Iraj applied and was appointed.

Flinders had the practice of allowing newly arrived academic staff to have a semester free of teaching but required that they give a seminar on their research. Iraj had done some very original work on resolving ambiguities in the nuclear forces by considering three nucleon interactions and he spoke about that. At the end of the seminar a third year student asked a question about the pion-two-nucleon three-body problem. This led to the student and Iraj making calculations of the model, each independently obtaining the same result. The student was Anthony (Tony) Thomas who had already published a paper on calculations of the (p,2p) reaction arising from a student project he had done with Ian McCarthy. Tony went on to complete a PhD under Iraj's supervision and was later appointed as Professor of Theoretical Physics at the University of Adelaide where he now holds the Elder Chair of Physics. Tony has said that he enrolled as an undergraduate student at Flinders after comparing the Adelaide and Flinders courses and deciding that Flinders had the fresher and more exciting offering.

When Peter Teubner arrived at Flinders he began construction of equipment for the measurement of electron scattering cross-sections. Erich Weigold arrived just over a year after Peter and began work on the (e,2e) project. Peter had already developed a good electron source that was suitable for the (e,2e) project, but the two projects proceeded in parallel, with Peter taking the lead on one and Erich on the other. By the end of 1972 both projects had produced results. The (e,2e) data were obtained within a year of the first successful measurements by a group at Frascati in Italy. Whereas the Italian measurements involved a solid carbon target and incident electrons with an energy of 9 keV, in the Flinders experiment 400 eV electrons were used to make the first observations of the emission of valence shell electrons from a gaseous target.

As the work developed, Ian McCarthy made comprehensive computations of electron collisions with atoms and ions, relishing his long sought collaboration with experimental work. Ian's first publication on the (e,2e) reaction appeared in 1973. For the remainder of his career he published prolifically and his papers were overwhelmingly on atomic, molecular or solid state physics with very few in his old field of nuclear physics.

The (e,2e) technique developed into a powerful probe of atomic and molecular structure in the form of electron momentum spectroscopy for atomic, molecular and solid targets. It was like a microscope that measured momentum rather than position. In 1988 McCarthy and Weigold obtained funding from the Commonwealth Special Research Centre program to establish the Electronic Structure of Materials Centre and their book *Electron Momentum Spectroscopy* was published in 1999.

Erich had come a long way since he was born in Haifa, Palestine. During World War II his family was shipped to an internment camp in Australia. At the end of the war they became migrants and settled in the Barossa Valley in South Australia. Erich's journey had taken him to the University of Adelaide and the ANU as a student, to the University of Adelaide as a lecturer, to USAFOSR as an administrator and to Flinders University. Erich was promoted to a personal chair and at the end of 1992 he left Flinders to become Director of the Research School of Physical Sciences and Engineering at the ANU. He retired at the end of 2002. In 2001 he was awarded the Centenary Medal and in 2009 was made a Member of the Order of Australia.

Peter Teubner continued his electron scattering work. His measurements of the differential cross-section for the elastic scattering of electrons from atomic hydrogen were the best available and he made similar measurements for the inert gases. By 1975 Peter and his students were working largely as an independent group studying inelastic electron scattering. They began making electron-photon coincidence measurements and observations of zero field quantum beats were made. Measurements of scattering from a range of atoms, particularly the alkali atoms, were directed at distinguishing between the accuracy of different theoretical calculations. In 2001 Peter was elected as a Fellow of the American Physical Society for his pioneering and outstanding contributions to experiments in electron scattering from atoms and molecules including the development of coincidence techniques and benchmark experiments on alkali targets.

Staff and students

The new Flinders University was like a clean slate. It could be planned without the constraints of tradition and in many ways it developed differently from the University of Adelaide. In the early days the staff, who came largely from outside the state, formed a close knit interdisciplinary community and they remember Flinders at that time as a wonderful place to be. The Vice Chancellor was popular. There were many social activities. The Ann Flinders Club was formed in 1965, named in honour of the wife of Matthew Flinders. It was very active in providing a supportive community for the wives of staff and for women staff.

Physics at Flinders had the challenge of establishing a reputation with prospective undergraduate and postgraduate students. It worked hard to develop innovative undergraduate courses and the program course structure was a forerunner of the multitude of specialised degree programs later offered by universities in the battle to attract students. In contrast to the Adelaide Department, the new research facilities did not have cupboards full of old components to be recycled. Max Brennan secured workshop facilities of a very high standard for the School of Physical Sciences and appointed skilled technical staff. Vice-Chancellor Peter Karmel encouraged research and Flinders developed as a research intensive university. Max developed an index of research performance based on research income from the major national research grant schemes that showed Flinders, for its size, compared well with Australia's best research universities.

At the University of Adelaide, the Department of Physics introduced a week-long summer school for students about to begin Year 12. There was a program of lectures, a keynote speaker and laboratory demonstrations. These summer schools were another of John Carver's initiatives and they were designed to present physics to students as a living discipline. At Flinders an annual summer school for teachers of secondary physics was established with the hope of pioneering new concepts in the teaching of physics, particularly in mechanics where 'the 19th century preoccupation with Newton's laws has led to a situation where physics as taught in schools and physics as understood by professional physicists are two different subjects'. Flinders also conducted a Physics Week when groups of school students came for a half day during which they were taken to a lecture and had the opportunity to use equipment in the first year laboratory.

The number of physics students grew rapidly during the 1960s. By 1967 the Adelaide Physics I class had tripled in size compared to 1960 and these numbers were maintained to the end of the 1960s. The average size of Honours Physics classes during the 1960s was 13, compared to 7 in the 1950s. The Department of Mathematical Physics had an average of more than 5 Honours students per year in the 1960s compared to a total of 7 students in the 1950s. This reflected a general growth of Australian universities under the funding regime of the Australian Universities Commission when most students received a Commonwealth Scholarship. It also reflected an enhanced interest in physics during the excitement of the international space race.

The first generation of Flinders graduates received their degrees in 1969 when 48 BScs were conferred. This grew to 93 in 1974. The first postgraduate student was Trevor Blackburn. He was an Adelaide graduate and had enrolled in the University of Adelaide at Bedford Park in 1965 and worked with Max Brennan in the Adelaide Department where he helped to build the first Flinders plasma source. After completing his thesis on ionizing shock waves he had a postdoctoral appointment in the Department of Electrical Engineering at the University of Liverpool and was then

appointed as a lecturer in the Department of Electric Power Engineering of the University of New South Wales where he rose to serve as Head of Department. The first Flinders student to submit a thesis for a PhD in physics was Peter Christiansen. He began his postgraduate study of the propagation of helicon waves in plasmas with Harry Blevin at the University of New England and moved to Flinders when Harry took up his appointment there. After graduating he went to a postdoctoral position at the University of Sussex and then was appointed to a lectureship. He died suddenly in 1992.

Two other postgraduate students, both Adelaide graduates, had submitted their theses by January 1970. Andrew Stirling worked on spectroscopic studies of plasmas and discharges under the supervision of Bill Westwood. After graduating he went to pursue a career in Canada where he worked for Atomic Energy of Canada Ltd, and for a while represented Canada at the International Atomic Energy Agency in Vienna. Ray Grimm enrolled following Honours in Mathematical Physics in 1965. He was supervised by Robin Storer and after completing a PhD on a numerical solution to the Schrödinger equation went to the Culham Laboratory of the UK Atomic Energy Authority. He then had an appointment in the Plasma Physics Laboratory at Princeton where he became a Principal Research Physicist and Professor. In 1984 he returned to Australia as a Senior Principal Research Scientist at the Australian Atomic Energy Research Establishment at Lucas Heights. He died suddenly later that year.

For the first few years most of the Flinders postgraduate students were Adelaide graduates, but in 1973 a landmark was passed when for the first time Flinders University awarded a PhD in physics to one of its own graduates. It was to Donn Jolly for work with Harry Blevin on the anomalous skin effect in plasmas. Donn subsequently went to the Royal Military College, Duntroon.

There was considerable turnover of lecturing staff in the Adelaide Department in the 1960s: 20 appointments were offset by 14 departures and the retirement of George Fuller at the end of 1963 after a career of 36 years since his appointment as assistant Lecturer in 1927. For many years his evening Physics I lectures were attended by those who hadn't understood the entertaining morning lecture by Professor Kerr Grant. He supervised undergraduate laboratories for many years. As a teacher, George was never noted as a source of inspiration or innovation, but he was valued for his clear and systematic presentation of the curriculum and is remembered with affection by many generations of students. George's retirement was marked by presentations to him and his wife at the Department Christmas party. A photograph taken on the occasion includes Professor Sir Kerr Grant who had retired in 1948, Professor Mark Oliphant and Dr Roy Burdon who had retired in 1958 also after a career of 36 years in the Department.

There were also arrivals and departures in the Department of Mathematical Physics. As already noted Ian McCarthy was appointed in 1960 and resigned in 1963. He was replaced by Patrick Seymour who, in turn, was replaced by Lindsay Dodd in 1968. Lindsay graduated with Honours in Mathematical Physics in 1961 and undertook a PhD on time delay in nuclear scattering theory with Ian McCarthy. In 1964 Lindsay was for a while Temporary Lecturer in the Department of Mathematical Physics and later in the year went to an appointment as Instructor at Yale University. There he collaborated with Ken Greider. When Ken went to a position at the University of California, Davis, Lindsay went with him to a postdoctoral appointment. It was from there that Lindsay accepted Bert Green's invitation to apply for a lectureship in Adelaide. In Adelaide, Lindsay's

interest was not in phenomenological work, but in the mathematical properties of the theory, testing the validity of approximations, testing limiting cases and studying soluble models. Later he worked on soliton models of nuclear particles. Another appointment was that of Harvey Cohen, who was a temporary lecturer from 1966 to 1969. He worked on field theory and had a passion for old Citroën cars, one of which suffered brake failure behind Lindsay Dodd's car.

Teaching learning and research

In the 1960s academic staff did the teaching and students were responsible for their learning. The lectures, tutorials, laboratory sessions and text-books provided students with opportunities to learn. The authority of academic staff to teach came, not from training, but from their expertise in the discipline which, in most cases, was enhanced by research activity. Conversely, research was often enhanced by the discipline of preparing lectures. This important link between teaching and research, that allowed physics to be practiced and presented as a living discipline, had emerged strongly in the Adelaide Departments during the 1950s as the research activity blossomed.

In the years since Professor Huxley arrived, the curriculum had undergone considerable change. In particular, topics in modern physics had been introduced. In 1950 Professor Kerr Grant's *Lectures on physics*, which had changed little since the first edition of 1913, still defined the scope and subject matter of the Physics I course, but by 1960 the course was defined by lectures based on a formidable set of prescribed text-books and included a section on modern physics. A program of lectures for Honours students had been introduced in 1950, given largely by Honours graduates from the previous year. In the Department of Physics it was Stan Tomlin and Harry Medlin who took the lead in developing courses in quantum theory at all levels. The advent of the Department of Mathematical Physics was an important step, giving Adelaide students access to the advanced teaching, particularly by Bert Green and Angus Hurst, in a remarkable range of fields.

The process of change continued during the 1960s. The keeping of attendance rolls at lectures was abandoned. Lectures on introductory quantum mechanics and the special theory of relativity were introduced into the Physics I course. By 1970 a single text-book, *Physics* by Resnick and Halliday, was recommended for Physics I. It belonged to a new generation of texts from the United States that were designed to make their contents more attractive and accessible to students. The *Berkley Physics Course* used at Flinders University was another example of the new physics texts. At Level III the courses were unitised and students given some freedom to choose the topics they studied. The Department of Physics offered nine units and the Department of Mathematical Physics seven. Six units were required for a third year subject and both departments had two subjects, each with some prescribed units.

At Flinders University only Part I (the first year course) was offered in 1966 and over the following three years the higher levels were introduced sequentially so that Part IV (Honours) began in 1969. From the beginning Physics I included special relativity and elementary quantum mechanics. The courses at higher levels were presented as sets of unit topics and included courses designed for students enrolled in an advanced physics program. Parts III and IV included courses in plasma physics, reflecting the research interest of the School.

In the Adelaide Department of Physics it was generally assumed that any member of the lecturing staff was able to teach any first- or second-year topic. However, lecturing at these levels presented

particular challenges and lecturers were chosen with care. First-year classes were large and holding the interest of students was an art. The best lectures had an element of a theatrical performance about them and some qualities of showmanship were an asset to the lecturer. Students responded to lecturers who showed interest in them, were passionate about their discipline and were patently competent in it. Second-year lectures were theatre on a smaller, less demanding scale.

Third-year and Honours lectures were different. The classes were small, the lectures were more like a conversation and a link with research experience was more important, especially when topics were presented as a set of specialised units. So specialised were some Honours units that they were not offered when the member of staff who normally gave the lectures was absent on study leave.

These arrangements for teaching and learning, in which teaching was strongly linked to research and learning was left to the initiative of the student, were most effective with able and committed students. In the 1960s students enrolling in physics courses were drawn from school leavers whose achievement was in the top few percent so that most students were, at least, able. Later the participation rate in university education rose rapidly and physics students represented a much wider range of achievement at school. It also became increasingly common that in addition to full time study students supported themselves with a part-time job. Together these factors led to a general decline in the ability, commitment and success of students. Sometimes it seemed that many students no longer understood what it meant to understand physics, but always there were outstanding students who excelled.

Of course lecturers were a mixed bunch and the relationship between teaching and learning was complex. Basil Brigg's careful choice of words and immaculate blackboard work meant that students went from a lecture with excellent notes having learnt much. Angus Hurst's lectures were uncompromisingly mathematical and he could write more quickly on the blackboard than most students could write on paper. His presentations were brilliant but most students were too preoccupied with note taking to learn much during the lecture. Harry Medlin was different again. His lectures were interesting but this was at the expense of systematic treatment of the topic. Students had to rely on a text-book for that. Harry was a thinker and he was interested in the great principles of physics. His lectures were discourses on the things that caught his imagination. Learning was in the realm of the imagination; some students were inspired, others confused. At the recent memorial service organised by the University to honour Harry, his postgraduate student Peter Colman said: "Harry, you taught me nothing, but what I learned from you shaped the whole of my life."

In later years universities sought to take greater responsibility for the quality of both teaching and learning. Student assessments of teaching were introduced and awards for outstanding teaching were given more prominence. Experiments were conducted in alternative formats for the presentation of introductory courses that were carefully designed to facilitate learning. An example of this was the trial of a Studio Physics program in the Department of Physics in which lecture, tutorial and laboratory were merged into a single learning centred experience. As it became vital that universities competed successfully to attract both local and overseas students, their recruitment programs included much rhetoric about learning being a distinctive, high quality experience for their students. In these times the Office of the Deputy Vice-Chancellor (Academic)

included specialists in learning and teaching methods whose task was to promote interest in these matters.

However, the relation between teaching, learning and research was still complex. There were still students who memorised much and learned little and there were students whose learning was deep and sometimes surprising. In times when universities downplayed the importance of academic disciplines, the custodians of one of the greatest of them all still sought to present physics as a living discipline. Their teaching was enlivened by their research and they provided the path for physics students to become physicists.

Carver and the University

John Carver made a considerable impact on the University of Adelaide. This was a result of his personality and leadership skills. He had a strong sense of the University as a community. After his arrival he quickly formed a set of social connections with key people, especially in the Departments of Mathematical Physics, Mathematics and Chemistry and at WRE, a process that seems to have been aided by a concentration of their homes in the Eastern suburbs of Adelaide.

John participated fully in the life of the University. He served as Dean of Science, was a member of the University Council for several terms and was Chairman of the Education Committee. This was during the University's strongly democratic phase when the Education Committee made important decisions. There were vigorous contests with Professor DO (Doj) Jordan, of the Department of Physical and Inorganic Chemistry and other leading academics.

John's leadership style was uniquely his. He strode tall, never shouted, worked with departmental government and achieved much. He had an ability to get the best from people. If there was a dispute in his Department, he would handle it with a gentle rebuke followed by a lot of encouragement and wise advice. At Honours examiners' meetings he was invariably the advocate for any student whose result was close to the threshold for a First. He had an especially good working relationship with Vice-Chancellor Henry Basten, from whom he obtained, early on, advice in finding his way through the politics of the University and developing strategies to attack problems.

Building projects during Carver's years were important for the expanding discipline of physics. The Bragg Laboratories were built in 1962, soon after his arrival. Although this relieved pressure on space, it was clear that more space was needed and a plan was developed to build an annex to the physics building. John had invaluable assistance in negotiating University support for the project from his Departmental Executive Officer, Peter van Rood. Peter was an interesting straight-talking character who had been an RAF spitfire pilot during World War II, had been taken a prisoner of war by the Germans and held in the high security prison at Colditz Castle, had worked for Royal Dutch Shell and came to the Department as a formidable negotiator. Construction of the Physics Annex, later to be named the Oliphant Building, was approved and it was built in two stages: the first in 1968 and the second in 1972. Thus it was that in a decade the space available to the Departments of Physics and Mathematical Physics was more than doubled.

As the ground floor slab of the first stage of the Oliphant Building was poured, the foundation for another of Carver's ambitious projects was included. It was the construction of the world's largest scanning vacuum ultraviolet monochromator, planned to have sufficiently high resolution to permit

measurement of the strengths of individual rotational lines in the absorption spectrum of molecular oxygen. These data was needed for accurate modelling of the rate of production of ozone in the atmosphere. The new monochromator had an optical length of 6.6m and to isolate the optical components from ground vibration they were mounted on a 40 tonne slab of concrete resting on an air suspension system. Early design work for the '6-m monochromator' was undertaken by Gerald Haddad who had an appointment as Temporary Lecturer in 1967 after completing his PhD in the Space Laboratory earlier that year. After Don McCoy completed his PhD in Stan Tomlin's solid state physics laboratory in 1966, he became interested in the technical challenges presented by the new instrument. He took up a temporary lectureship in the Department and joined the Space Group. At the end of 1967 Gerald left to take up a postdoctoral appointment at the University of Nebraska in the USA and it was left to Don and a very able technician, Frank Smith, to solve the design problems.

Gerald Haddad later returned to work for the CSIRO at Lindfield, NSW, where he became Chief Industrial Physicist. Recently he and three CSIRO colleagues were tragically killed in a helicopter accident near Sydney.

The demands of precision required by the new monochromator were met by mechanically separating the control of the scanning and focus adjustments and linking them electronically, using a desktop calculator in the first instance. The construction of the elaborate housing for the diffraction grating was undertaken in the Department workshop that had expanded rapidly during the activity of the rocket program from three technical staff to fourteen. The range of equipment and skills needed for the monochromator project were now there. By the time Don McCoy took study leave in the UK in 1976 the instrument was complete. It came very close to achieving the design objectives, but in practice its performance was limited by the intensity of the sources of ultraviolet radiation that were available. During 1976 Brenton Lewis, a graduate of the Department and then a Queen Elizabeth II Fellowship holder, made the first photoabsorption measurements with the monochromator.

The new monochromator was used to successfully measure the strengths of rotational lines in the complex oxygen spectrum. Subsequent work ranged from atmospheric applications of the data to study of fundamental molecular dynamics. On the one hand there was computer modelling of the production of atomic oxygen by the photodissociation of oxygen in the atmosphere and work on the evolution of atmospheric oxygen and ozone. On the other there was the measurement and theoretical modelling of spectral lines in the photoabsorption strength of diatomic molecules in cases where the coupling of quantum states has dramatic effects on the line width and shape. Don McCoy's colleagues in this work were Lee Torop and Alastair Blake. Lee was appointed to a lectureship in 1967 after completing a PhD on the angular distribution of gamma-rays at Stanford University. He provided theoretical support for the project. Alastair was appointed to a lectureship in 1970 after a postdoctoral appointment at Imperial College, London. In due course the 6-m monochromator was made obsolete by the development of intense high resolution scanning laser sources of UV radiation and it was dismantled.

When, in 1971, Mark Oliphant was appointed Governor of South Australia, he renewed his interest in the Department he had left almost 50 years earlier. John Carver's relationship with his old mentor resumed and distinguished visitors to the University were accommodated at Government House. John's long relationship with Oliphant was very special to him. He received guidance and advice

about his career and about strategy and leadership. When, in 1979, Carver was appointed to Oliphant's old position of Director of the Research School of Physical Sciences at ANU it must have seemed a fitting climax to his career but, according to his wife Mary, no appointment gave him more pleasure than the offer of the Elder Chair of Physics in Adelaide.

John Carver had a most distinguished career. Apart from his work with COSPAR and the United Nations, he was chairman of the Anglo-Australian Telescope Board, Deputy Chairman of the Australian Science and Technology Council, Chairman of the Radio Research Board of Australia, Chairman of the Australian National Committee for Space Research, Chairman of the Australian National Committee for Solar Terrestrial and Space Physics, and President of the Physics Section of Australian and New Zealand Association for the Advancement of Science. He was a Fellow of the Australian Academy of Science, a Fellow of the Australian Academy of Technological Sciences and Engineering and a Member of the International Academy of Astronautics. He was a Fellow of both the Australian Institute of Physics and the Institute of Physics, a Member of the International Astronomical Union and of the Astronomical Society of Australia. In 1986 he was made a Member of the Order of Australia (AM) and he was awarded a Centenary Medal in 2001.

In 2000 Carver was awarded the COSPAR International Cooperation Medal for his distinguished contributions to space science and his significant contribution to the promotion of international scientific cooperation. It was conferred at the 33rd COSPAR Assembly in Warsaw that also celebrated the 500th anniversary of the work of Copernicus. John was, by this time, quite ill and was accompanied to Warsaw by Mary. He died in December 2004.

The good old days

There were many developments during the 1960s. They were exciting times. A new University was founded and acquired its own character while still relatively small. At Adelaide research initiatives of the 1950s were consolidated and new initiatives launched. The postgraduate students who did the foundation work in the new areas could still be given the freedom to establish a new area of work. It was a time of flux as new staff appointments were made and others moved on to opportunities elsewhere. The diversity of research expertise and of technical skills and facilities expanded rapidly. Access to research funding was easier than it had been in the 1950s. In 1965 the Federal Government established the Australian Research Grants Committee with a budget of almost \$4 million. The advent of space exploration with its super power rivalry culminating in the race to the moon made physics the glamour discipline among the sciences. It is tempting now to say that these were the good old days.

After the 1960s had passed, many things changed. The style of research changed as emphasis shifted to large group research. Funding bodies began to favour interdisciplinary work. In response, research institutes were formed and international collaborations provided access to resources and opportunities beyond the scope of local funding. Sometimes this was a survival strategy and sometimes the result of the natural development of projects toward more ambitious challenges as, for example, the focus of the cosmic ray air-shower work at Adelaide moved toward cosmic rays of the highest energy and collaboration in the High Resolution Fly's Eye project based at the University of Utah. At Adelaide the era of departmental government gave way to a new managerialism. The inadequacy of Government funding drove universities toward a corporate structure in their senior

management. As institutional survival became a challenge, a divide rather like what geologists call an unconformity developed between the senior management and the academic community.

In such a climate the University of Adelaide did not value its small Department of Mathematical Physics as it had when excellence was enough. With successive retirements the Department was first merged into a new Department of Physics and Mathematical Physics and then lost in a School of Chemistry and Physics. For the first time since the Elder Chair of Physics was established, the University did not have a Department of Physics with a budget. The strong discipline-based department had served the University well, but now it seemed that physics as a precious and distinctive way of thinking, as a coherent discipline and not just a set of research projects, was no longer valued in the same way.

In 1984 Tony Thomas took up a third chair in the Department of Physics. Tony's field was theoretical high energy particle physics and he had links with the Canadian TRIUMF and European CERN facilities. He succeeded in the climate of the time by obtaining funding from the Australian Research Council to establish the Special Research Centre for the Subatomic Structure of Matter.

As time went on, the fortunes of physics changed with regard to student enrolments. With the genomics revolution the biological sciences took on the glamour that physics had enjoyed in the 1960s, and physics enrolments declined. When the professional disciplines replaced science subjects with professional subjects, considerable student load was lost. This meant a considerable loss of funding.

In comparison to this, the 1960s were simple. Academic values reigned and senior academics were key figures of the University. In physics there was the towering leadership of Carver, the brilliance of Green and Hurst, the astute guidance of Brennan, the creative energy of McCracken, the finesse of Jacka, the enthusiasm of McCarthy and the quiet mastery of Briggs. These were the things that made the 1960s a special decade for physics in Adelaide.

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Alastair Blake
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