BIOGRAPHICAL MEMOIRS OF FELLOWS OF THE ROYAL SOCIETY

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Elected FRS 1951

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Maurice Pryce was a mathematician and theoretical physicist who became one of the most able and versatile of his generation. The inspiration that guided the development of his career came partly from his family and later from his teachers and mentors, many of whom had international reputations of the highest order.

Maurice's father was born in Swansea, half Welsh and half English. He developed an early interest in physics and mathematics and took a degree in mathematics at Cardiff University, where subsequently he was for a short time a lecturer in mathematics. He had the ambition to become a theoretical physicist, but gave in to family pressure and became a civil servant, first at the Patent Office, then at the Air Ministry, and during World War II with the Ministry of Aircraft Production. In 1912 he married Hortense Elvire Lecorney, whose home was at Argentan (Orne) in Normandy. They had three sons, all of whom were given French first names: the middle son was Jacques and the youngest Jean-Michel. Their father was an excellent linguist and at home habitually spoke French; later, Maurice was always quick to point out that this was his first language. One of Maurice's research students at Oxford, Russian-born Anatole Abragam (ForMemRS 1983) in his autobiography (Abragam 1989) wondered how it was that such a well-educated man as Maurice spoke French 'with the accent of a Normandy peasant'. Maurice's riposte was 'But I *am* a Normandy peasant'.

The Pryce family lived in comfortable middle-class surroundings, first at Croydon, where Maurice was born. In 1920 they moved a short way out of London to Guildford, and starting in the following year Maurice spent 16 months with his maternal grandparents in Argentan. It was at about this time that Maurice was asked what he wanted to do when he grew up. His reply was 'I want to find out how things work'. In later life he commented, 'If you can find a better definition of a theoretical physicist, tell me'.

Back in England he spent some time at a primary school and then attended, from 1923 to 1929, the Edward VI Royal Grammar School in Guildford. It was here that his scholastic

ability became apparent, and he held a King's Scholarship at the school during his last four years. He paid tribute to his mathematics teacher, Tudor F. Jones, who encouraged him to study beyond the normal school syllabus under his guidance; as a result in three successive years from 1926 to 1928 Maurice won school prizes for mathematics. Among his extracurricular activities he was a Boy Scout, achieving First Class Scout status in 1927 and becoming a Patrol Leader in the same year. He played chess at the school and became Chess Captain in his last four years. There is no evidence that he maintained an interest in chess, but later in life he enjoyed card games such as Bridge and 'Hearts'. Eventually Scrabble became his main leisure relaxation. He insisted on playing 'collaborative Scrabble' in which the total score was important, not the players' individual scores. He took lessons in piano playing from a private teacher during his time at school, became a competent pianist and enjoyed playing the sonatas of the classical composers until his late years.

As the eldest of the three boys Maurice paid great attention to his brothers (there was an age gap of six and a half years between him and the younger of them, Michel). Summer holidays were spent at Rothéneuf on the Brittany coast near St Malo, and he taught his brothers how to swim and the techniques of dinghy sailing and sea fishing. At home in Guildford he converted the garage into a chemistry laboratory and indulged in dangerous pursuits such as the distillation of ether and the manufacture of gunpowder; the latter was used in a toy cannon fired from a distance by the use of an ignition coil. He mended clocks and even knitted a warm jacket for one of his brother's toy animals, a cow—this must have been a nice topological exercise for a budding mathematician. It was perhaps these practical matters that later made him inquire into the details of the experiments that were related to the subject of the theoretical problem on which he was working.

Maurice left school in the summer of 1929. His father held the view that 'German is the language of science' and arranged for Maurice to spend a few months at Heidelberg to learn the language. He was accepted into the household of Professor von Klintzberg, an Austrian nobleman whose subject was mediaeval German law and who gave seminars at his house at five o'clock in the morning. Maurice left Heidelberg 'speaking the 18th century German of Goethe', and in October 1930 entered Trinity College, Cambridge, with a State Scholarship and a college Open Exhibition in Natural Science.

## Cambridge and Princeton

At Trinity College Maurice worked for the mathematics tripos under the supervision of Sir Ralph Fowler FRS and Abram Besicovitch (FRS 1934). During his first year the standard of his work under their guidance resulted in his election to a Senior Scholarship, a step up from his Exhibition. He took first-class honours in part I of the tripos in 1931 and again in part II in 1933, and was judged to be the cleverest student of the past 15 years. Of his supervisors he said, 'I owe a great deal for their stimulus'. After graduating he started research in Cambridge, first for two terms with Fowler and R. H. Hulme on the theory of internal conversion in nuclear decay, then with Max Born (FRS 1939, Nobel laureate 1954). In 1935 he was awarded a Commonwealth Fund Fellowship (now a Harkness Fellowship) at Princeton University. He relates how, after the voyage across the Atlantic, he spent a week in New York being spellbound by the breathtaking sights of the city before going on to Princeton. He arrived there at four o'clock on a Saturday afternoon and was greeted by the Dean of the Graduate School

who, after an early dinner, took him to the residence of one of the professors who kept an open house on Saturday evenings. He later recalled, 'So there I was, after less than four hours at Princeton, being made to play one of the pianos in a Bach three-piano concerto with people I had never seen before.' (This was no doubt one of Bach's concertos for three harpsichords; Princeton had to make do with three pianos.)

During his first year at Princeton Maurice worked with Wolfgang Pauli ForMemRS (Nobel laureate 1933) and subsequently with John von Neumann. He had taken with him a letter of introduction from Max Born to Albert Einstein ForMemRS (Nobel laureate 1922). In 2001 Maurice remembered the occasion when he took the letter to Einstein:

> I screwed up my courage and I went and knocked on Einstein's door. I had the letter in my hand, and I handed it to him. He briefly glanced at it, and said 'Welcome. This is Doctor Rosen, and we were discussing the following situation' and showed me something on the blackboard, and said 'What do you think of it?' I immediately decided that this man was a complete saint, and I have adored him ever since, and I haven't changed my mind about that. I have on occasion had dinner at his house with my wife, and I have been cheeky enough to say to Einstein 'I don't think that is right', but he didn't take offence at all.

Maurice had a great sense of humour and appreciated the humour of others. He told a story of his time at Princeton, where he played tennis with a Cambridge acquaintance, the renowned mathematician G. H. Hardy FRS, who was at Princeton on leave from his fellowship at Trinity College. One morning Maurice received a telegram informing him that he had been elected to a fellowship at Trinity College. Later that day, walking with Hardy to the tennis court, Maurice told him the news. Hardy's response was 'Now that we are social equals I suggest we play for money'.

At the end of his time at Princeton Maurice successfully submitted a thesis for the Degree of Doctor of Philosophy entitled *The wave mechanics of the photon*. Back in Cambridge in 1937 he was both a Fellow of Trinity and a Faculty Lecturer in Mathematics. He worked on the new field theory of Born and Infeld (1)* and wrote a doctorate thesis that was approved by the university, but he did not go through the ceremony of investiture in the Senate House; he considered that 'one PhD is enough'.

Of Max Born, Wolfgang Pauli and John von Neumann he said, 'Their influence has been decisive for my career; to them I owe an incalculable debt'. A subject that caught Maurice's attention at about this time was the two-neutrino theory of the photon, which he showed was erroneous (2). Paul Dirac FRS (Nobel laureate 1933), then a professor of mathematics at Cambridge, was impressed by Maurice's work and suggested that it should be published in the *Proceedings of the Royal Society.* Maurice considered that this was the high point of his career.

## Liverpool and wartime

Maurice had arranged with Niels Bohr ForMemRS (Nobel laureate 1922) to spend a year with him in Copenhagen, but the threat of war and its subsequent outbreak led to the visit's cancellation. In 1939 Maurice married Susanne Margarete, a daughter of Max Born. They had one son and three daughters. Of these their son John inherited Maurice's mathematical genes, read mathematics at Trinity College, Cambridge, and is a lecturer at Cranfield University. Also in

* Numbers in this form refer to the bibliography at the end of the text.

1939 Maurice accepted a readership in theoretical physics at Liverpool University, where the head of the department was Sir James Chadwick FRS (Nobel laureate 1935). In that year World War II started and Maurice was active in Liverpool for only two years, studying, after the discovery of nuclear fission, the feasibility and internal mechanics of the fission bomb. He repeated, using more accurate values for the relevant parameters, the calculations of Rudolf Peierls (FRS 1945) and Otto Frisch (FRS 1948) on the feasibility of a nuclear bomb and the energy that would be released. He was horrified by his result, and decided never to be involved in work that might lead to the construction of such a bomb.

In Chadwick's laboratory Maurice necessarily became involved in the wider aspects of nuclear physics, and this gave a fresh impetus to the already broad field of his interests. Soon other topics were considered to be of higher wartime priority, and in 1941 he was directed to work at the Admiralty Signals Establishment (ASE) at Nutbourne in Sussex, one of the wartime centres for the development of radar.

Up to that time the practical aspects of that branch of electromagnetism that is concerned with the generation and propagation of radio waves had been restricted by the available techniques to a wavelength no shorter than about 1 metre, generated by vacuum tubes of the triode variety. The general principles of radar as a means of locating aircraft were understood, but it was realized that shorter wavelengths would be needed if its effectiveness was to be increased. The breakthrough came with the development of the pulsed microwave magnetron and the klystron, which between them provided a transmitter and a receiver of wavelengths of the order of 10 centimetres and shorter. Here the then well-established radio techniques were not feasible: hollow conductors—waveguides—had to replace transmission lines for conveying electromagnetic energy, and half-wave dipoles had to be replaced as transmitters and receivers of electromagnetic waves by an open-ended horn generally provided with a parabolic reflector to produce a narrow transmitted beam. From 1941 to 1944 Maurice was concerned with this field and was quick to develop the theory of such configurations. Of this period of his career he wrote:

> From 1941 until 1944 my training in classical electrodynamics helped me to collaborate in a rapidly evolving technology where the more orthodox radio engineer found difficulty in adapting to wave and field concepts in the design of equipment. My almost total ignorance of radio techniques was a help rather than a hindrance.

The value of radar in the conduct of the war is undeniable, and Maurice was responsible for no small part of it by providing assistance in the design of microwave components, which had become essential features of microwave radar.

Before centimetric wavelengths became available, the Germans devised a method for guiding bombers to their targets in England. This involved transmitting intersecting radio beams from transmitters situated on the coast of occupied France and Belgium using frequencies initially of 30 MHz and later about 60 MHz (wavelengths of 10 m and about 5 m). Experts, among them Frederick Lindemann FRS (later Lord Cherwell), Churchill's scientific adviser, had the view that most of the likely targets would be beyond the range of such short wavelengths; it was thought that only line-of-sight communication between transmitter and receiver was feasible. In practice this is true of centimetric wavelengths, but the successful use of the technique in bombing Midland targets in England by aircraft guided by radio beams transmitted from Channel coastal stations in occupied Europe showed that in fact at longer wavelengths it was a wrong supposition. Maurice, working at the ASE, produced a theory, and Cyril Domb (FRS 1977) (6) performed the necessary computation, showing that waves at the

frequency used by the Germans would in fact be diffracted sufficiently to follow the curvature of the Earth; this accounted for their unexpectedly long range. Fred (later Sir Fred) Hoyle (FRS 1957), one of Maurice's research students at Cambridge who had been with him at the ASE, described Maurice's proof as 'the most awesome piece of mathematical virtuosity I ever saw' (Hoyle 1997). It was published after the war (7) and there Hoyle's comment can be seen to be amply justified.

During the war efforts were made, unsuccessfully, to get Maurice involved in work that was specifically directed towards the design and construction of a nuclear bomb. In 1944 he joined the British atomic energy team in Montreal on the design of nuclear reactors, and was later responsible with E. A. Guggenheim (FRS 1946) for the design of the first British reactor, codenamed BEPO, at the Atomic Energy Research Establishment (AERE) at Harwell (5).

After the end of the war an official report was received that Maurice's brother Jacques had died while on active service in the Far East, but no details of the circumstances of his death were given. The tragedy greatly affected Maurice, and it was not until many years later that he learnt from one of Jacques's brother officers that as a result of a nervous breakdown Jacques had committed suicide three days before the end of the war against Japan.

Maurice returned to Cambridge in 1945 as Fellow of Trinity College and Lecturer in Mathematics, but his tenure of these posts was brief. At Oxford the Wykeham Professorship of Physics had been held since its inception in 1900 by John Townsend FRS, with no statutory retiring age. Townsend was knighted in 1941 and, as a result of pressure from the university, resigned in the same year, but the chair was left vacant during the war. Townsend was an experimentalist and head of the Electrical Laboratory and had not been associated with Lindemann, the head of the Clarendon Laboratory. The university was persuaded that the need for a professor of theoretical physics was overwhelming; the subject associated with the Wykeham chair was changed accordingly. The Electrical Laboratory was amalgamated with the Clarendon Laboratory under the headship of Lindemann. Maurice was an obvious candidate, and in 1946 he was elected to the chair, and with it a Fellowship at New College. He was 33 years old but looked so much younger than this that soon after his arrival in Oxford, while drinking in a pub, he was mistaken for an undergraduate by the Proctors.

## Oxford, Bristol and the University of Southern California

Once in Oxford Maurice rapidly built up a large group of research students. At that time there were many returning from war service in the armed forces and reserve scientific occupations, and they were all anxious to get on with their studies. Some of these were attracted by Maurice's reputation, others simply by the opportunity of working in Oxford. His two most successful students, who according to Maurice were both cleverer than him, were Anatole Abragam, who came to Oxford from France because he thought it sounded a more attractive city than Birmingham, and John Ward (FRS 1965), who had begun to work on practical matters in the Engineering Department in Oxford with Professor Thom, whose main interest was the investigation and interpretation of megalithic sites in Britain.

Ward made seminal contributions to field theory even while still a student, but he was so brief in his explanations that people found it difficult to grasp his brilliant ideas. Maurice played an important role in developing these ideas in an understandable way, as in their joint paper on angular correlation effects (3). Maurice also made important contributions to the

development of the shell model of nuclei; several of his students, notably Roger Blin-Stoyle (FRS 1976) and David Brink (FRS 1981), built extensively on these foundations. His main area of research, however, became the study of magnetic ions. Extensive results with the use of paramagnetic resonance were being obtained in the Clarendon Laboratory with the microwave techniques developed there in wartime for radar. In particular the hyperfine structure, discovered by R. P. Penrose shortly before his untimely death, proved extremely interesting but a difficult theoretical challenge. For example the divalent Mn ion in an $S_{5/2}$ state showed a rich hyperfine structure where elementary theory predicted none. The answer lay in the mixture of s-electrons to the configuration. In this and many other ways he and Abragam laid the essential theoretical foundations of the subject (4). Other students working in this area were Kenneth Stevens, Roger Elliott (FRS 1976) and Mary O'Brien, and John Ziman (FRS 1967) was another member of this group working in magnetism. Maurice's supervision technique was to offer only broad advice and let his students find their own specific problems. Although this was conspicuously successful in some cases there were also casualties who ended up with what were effectively insoluble problems for the time. During this period there was only one other permanent appointment in theoretical physics, Stanley Rushbrooke (FRS 1982), whose interests and knowledge in thermodynamics and statistical mechanics gave useful support to Professor Simon's low-temperature group in the Clarendon Laboratory. Cyril Domb, who had worked with Maurice at the Admiralty, held a short-term position, as did Kenneth Stevens with a postdoctoral fellowship. All of these were eventually tempted away to chairs in other universities. Nevertheless there was an adequate core to make for a very active theoretical physics group drawing its ultimate inspiration from Maurice. He instituted regular seminars, a journal club and graduate lectures to increase the understanding of theoretical physics across the board for both theoretical and experimental students.

Early in 1950 Klaus Fuchs, the head of the theoretical physics group at the AERE at Harwell, some 10 miles from Oxford, was arrested on a charge of communicating to the Russians secret information related to the development of the atomic bomb. Until his successor at the AERE was appointed, Maurice served part-time as acting head of the theoretical physics group. Of this period Rudolf Peierls says of Maurice in his autobiography (Peierls 1985):

> He was well qualified for this because of the breadth of his knowledge and interests. He could be a devastating critic, and it is said that after each of his visits to Harwell someone had to go round to comfort the young people he had seen and assure them there was still a chance that they might turn out to be competent theoreticians.

Maurice was renowned for the critical remarks he made at the conclusion of seminars and colloquia that were shattering for the speakers and embarrassing for the audiences. Research students, giving a routine talk about their work, would be fearful that Maurice might be present.

Maurice became increasingly frustrated by his position in the Clarendon Laboratory, where every administrative and financial decision had to be referred to Lord Cherwell as its head. Accommodation for the group in Townsend's old Electrical Laboratory was very cramped. There was little money for calculators, travel and secretarial support, and in particular there seemed little prospect of more permanent positions. Partly for these reasons Maurice accepted an invitation to replace Nevill (later Sir Nevill) Mott FRS (Nobel laureate 1977) as Henry Overton Wills Professor and Head of the Physics Department in Bristol when Mott moved to the Cavendish Chair in Cambridge. This was at the time considered to be a great loss for physics in Oxford.

His situation at Bristol was very different from that at Oxford. He had major administrative duties as head of a large laboratory, which he carried out most effectively. He masterminded the extension of the department into its new facilities and was active socially in helping the cohesion of the department, for example as an enthusiastic member of its cricket team. This gave him little time for his own research, although he continued an active study of magnetic ions, particularly those of the actinide group (8), and made important contributions to the study of the Jahn–Teller effect (9). But he took few new research students and his output of research papers declined. However, characteristically, he was always ready with pertinent and useful advice across the whole field of physics, and was a most stimulating protagonist for all who would fight their corner. He came from that last generation of theoretical physicists who had grown up in the 1930s when everything flowed from the new interpretations provided by quantum mechanics.

In 1964 he again made what, to some, seemed a surprising move by accepting a position as Distinguished Professor of Physics at the University of Southern California (USC). This may have been partly engendered by financial difficulties after his divorce and his marriage to Freda Kinsey, the former wife of Bernard Kinsey, an ex-Cavendish nuclear physicist who had settled at the University of Texas at Austin after a period at the atomic energy establishment at Chalk River in Canada.

Physics at USC was not highly developed and the department was part of the Electrical Engineering Faculty. Initially it seemed that he had a mandate to build, essentially from scratch, a first-class department, but in reality neither the will nor the funding was available and Maurice himself was not aggressive enough to exploit the position in which he found himself. Among his tasks was to oversee the operation of the university's small proton linear accelerator and to negotiate with a consortium of other local universities to build a 150 MeV cyclotron. He did a limited amount of personal research, mainly relating to the interpretation of the properties of defects in semiconductors as studied by the experimental group of W. Spitzer, but he was fundamentally unhappy and after four years there he seized an opportunity to move to the University of British Columbia when that was presented in 1968.

## Vancouver

When Maurice was with the British atomic energy team in Montreal he got to know the theoretical physicist George Volkoff, who subsequently became head of the physics department at the University of British Columbia (UBC) in Vancouver. Many years later Maurice met Volkoff at a conference and mentioned to him his anxiety to move on from the University of Southern California. Maurice was then in his mid-fifties and was looking forward to spending his time until retirement in a post with a minimum of administrative duties. Volkoff mentioned the possibility of a chair in the physics department at UBC and invited Maurice to give a paper at one of the annual conferences held there. Maurice accepted, and this gave him and his wife, Freda, the opportunity to visit Vancouver. Maurice commented, 'It is the sort of place where one can contemplate growing old gracefully'. After hearing the details of a possible appointment at UBC Maurice made a formal application. His referees were Rudolf Peierls, who at that time was the Wykeham Professor at Oxford, Cecil Powell FRS (Nobel laureate 1950), who had succeeded Maurice at Bristol, and Maurice's former research student Anatole Abragam, who then held the Chaire de Magnétisme at the Collège de France. All wrote with the highest

and unreserved praise: '… without any doubt he is, as a physicist and as a person, a man of the first rank; … a most eminent and distinguished physicist whose range of thought and competence is very wide … one of the best all-round theoreticians I know, a man who is conversant with all the branches of modern physics.' There could be little doubt that UBC would make him an offer, and when it came Maurice accepted; the agreed starting date was 1 September 1968, and he and Freda moved into a house in a quiet situation near the edge of the strip of woodland that separates the campus from pleasant residential suburbs.

As a full Professor in the physics department Maurice was required to undertake a certain amount of teaching and research and was a member of the body of senior academic staff who administered the department under the head; these duties were light and Maurice performed them conscientiously. He was particularly effective on one occasion during his early years at UBC when student unrest was widespread in universities. Within the physics department Maurice was asked to act as chairman of a committee set up to deal with the dissatisfaction of the students and the younger members of the department. One member of this committee, Brian Turrell, who later became head of the department, remarked, 'Maurice did a very good job in running that committee and afterwards ensuring that its recommendations were implemented. The result was a much more democratic department and a happier one.'

## Final years

In the 10 years between his arrival at UBC and his retirement in 1978 Maurice published only three papers, but this small number cannot be taken as an indication of the extent of his activity in research. He spent a great deal of time in the department, regularly attended departmental colloquia and proved to be an invaluable asset to both physicists and astronomers. After retirement he was given office space in the physics department and continued to give the benefit of his exceptional ability in discussions on a wide range of topics, but invariably insisted on satisfying himself that he understood the details of any experiment before considering its theoretical implications. His presence in the department was greatly valued; his range of interests ranged widely from astrophysics to atomic and molecular photoionization. One of his last interests was the theoretical explanation of the observed spectrum of the OH radical. When presented with this problem he was deceived by its apparent simplicity and considered it to be 'a weekend exercise'; in fact it remains unsolved.

Maurice's reputation for his outspoken criticism, both in private and in public, of the work of others had followed him, but there had been a change. Brian Turrell commented, 'I am sure that Maurice still found it difficult to suffer fools, but he did listen to anyone with a problem and did his best to help. I would say that he was actually generous in his dealing with colleagues.'

After his retirement, Maurice accepted membership of a Technical Advisory Committee of the Atomic Energy of Canada Ltd. This was concerned with nuclear waste management, such as the possibility, particularly with respect to considerations of safety, of depositing nuclear waste deep in the Precambrian rock of the Laurentian Shield, which covers almost half of Canada. Although Maurice was not a trained geologist he was invited to serve on the committee as a man of wisdom and good judgement who could give an unbiased opinion on the proposals under discussion. He made use of his own expertise by collaborating in a theoretical study of groundwater flow in the Shield and the division of the Shield into disjoint cells with no movement of water between them.

Maurice's years in Vancouver proved to be ideally happy, at least until Freda developed cancer that failed to respond to treatment; she died in 1989. Maurice was devastated. Freda and Maurice had been well suited for each other; Freda had a firm character and Maurice had great respect for her.

The last four years of Maurice's life were spent in the University Hospital in Vancouver, incapacitated by osteoporosis-induced bone fracture and subsequent infection. During this period his mind was unaffected and he bore immobility and frequent pain with patience and good humour. He remained in exemplary good spirits and was visited daily by a close friend of long standing and six years his senior, Eileen Goldberg.

All four of his children and many of his friends were with him to celebrate his 90th birthday in 2003. He died six months later.

## An appraisal

Maurice sometimes expressed doubts as to whether he had conducted his life wisely. His main regret was that he had allowed himself to accept appointments that involved, in his estimation, an excessive amount of something he did not enjoy: administration. The Wykeham chair at Oxford at the time when he accepted it was almost completely free of this burden, but the head of the physics department, of which theoretical physics was a part, was Lord Cherwell, who had been appointed with no fixed retirement age. Cherwell was in a position to overrule Maurice and Maurice had little respect for him, which resulted in Maurice's decision to move. But, ironically, a short time after this took place Cherwell resigned and a separate department of theoretical physics was then created at Oxford; Maurice had lost the opportunity to negotiate for his autonomy in a department of his own. At both Bristol and USC he felt overwhelmed by the unexpected amount of administration involved, and his decision to move to the UBC brought welcome relief.

He had achieved an enviable reputation as a mathematician and theoretical physicist and at UBC he was free of any need for further ambition. One of his critics made the comment that Maurice was a solver of problems and showed little originality in his work. But his flair for solving other people's problems made him an invaluable asset to his colleagues and to his pupils: the subsequent careers of his research students are a sufficient indication of his success as a supervisor.

## Honours and appointments

1935 Fellow, Cambridge Philosophical Society
1936 Member, American Physical Society
1938 Fellow, Royal Astronomical Society
1946 Fellow, Physical Society (London); Member of Council 1959–61
1951 Fellow of the Royal Society
1957 Member of Radar and Signals Advisory Board, Ministry of Supply
1958 Member of Electronics Research Council, Ministry of Aviation
1959 Member (later Chairman) of the Advisory Council, Royal Military College of Science, Shrivenham
1960 Honorary Member of Council, Société de Physique, Paris

## Acknowledgements

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