

## MOSES BLACKMAN

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By D. W. PASHLEY, F.R.S.

MOSES BLACKMAN, or Morris Blackman as he came to be known by his friends, was South African by birth and arrived in England as a post-graduate research student in 1933. He made his home in England for the rest of his life. He was a solid-state physicist, primarily concerned with the development of lattice theory and its application to determine such properties as specific heats. For all but two years he spent his time at Imperial College, where he became heavily involved with the electron diffraction research group, which he eventually headed for over 20 years, following the departure of G. P. Thomson, the son of J. J. Thomson, to become Master of Corpus Christi College, Cambridge. He had worked very closely with G. P. Thomson, who recruited him as the department's theoretical physicist, on a variety of different topics. They developed a most fruitful collaboration, based upon a healthy mutual respect for each other's ability coupled with enthusiasm and devotion to physics. Blackman easily had his interest aroused in any branch of physics, and he found himself acting as a theoretical adviser to numerous of his colleagues in the Physics Department of Imperial College. This applied particularly to the period up to the late 1950s, by which time the expansion of the department allowed a new generation of theoretical physicists to be recruited.

### THE EARLY YEARS

Moses Blackman spent his early childhood in Cape Town where he was born on 6 December 1908, the son of Joseph and Esther Blackman. His father had emigrated from Russia at the beginning of the century, leaving all his relations behind. His mother's family had also emigrated from Russia around 1902, and had settled in Cape Town where her father had established a dairy.

In about 1915 Joseph and Esther and their family moved to Uppington



*Mr Blackman*

in Gordonia, where Joseph became Rabbi to the Jewish communities. At that time this was a tiny town, or village, on the north bank of the Orange River, in Cape Province, having one main street and one subsidiary street. Moses well recalled that the summer brought an arid dry heat, with occasional fierce dust storms sweeping in from the Kalahari desert. In the spring there was impressive flooding of the Orange river, with the river coming down as a huge bore due to rains in both the Transvaal and in Basutoland. From 1915 to 1921 Moses attended a small school in Upington, where most of the teaching was in Dutch of a form almost identical to the 'high Dutch' of Holland. At a later stage Afrikaans was introduced as one of the two official languages. By the age of seven he was already greatly interested in reading, which he did voraciously if rather indiscriminantly.

In 1921 the family moved once again to Grahamstown where Joseph Blackman also became Rabbi to the Jewish Communities and which, by comparison with Upington, was already a large city. It was an important educational centre, having several 'public schools' modelled on the English pattern as well as a fairly large normal school, Victoria Boys High School, which Moses attended. This was a very green area compared with the environs of Upington, because Grahamstown is situated in the coastal belt and has a good winter rainfall. Moses found it an interesting region in which to walk, with well-wooded areas around the town and a generally varied surrounding countryside. He was interested in his school work and consequently seemed to do well. At this stage his best subjects were languages, Latin and Afrikaans, and mathematics, which he attributed to his retentive memory combined with hard work. It appears that he had yet to acquire any special affection for physics.

As a result of his performance in matriculation in 1925 he was awarded the one scholarship available for the local university, Rhodes University College, which was then part of the Federal University of South Africa. He chose to read for the B.Sc. degree, which was of a general degree type with two major and several subsidiary subjects. The choice of a science degree, rather than an arts degree, was influenced partly by his headmaster, a Mr Vernal, and the feeling that science would offer more scope at a later stage, but probably also because he was conscious that though he learnt languages relatively easily, he was less interested in the stylistic side. He concentrated on physics, mathematics, applied mathematics and German, the latter because he considered that it would be useful to be able to read German scientific textbooks. He saw a great deal of the Professor of German, who was the sole academic member of the department, and made such good progress with the subject that he took German as a major subject in addition to mathematics and physics. He achieved firsts in all three.

He continued with the M.Sc. course in physics and, being the only student, received individual tuition from Professor Varder and Dr

Watson, both of whom had had research experience under Rutherford. Again he achieved a first. As a part requirement of the course he submitted a dissertation on the quantum theory of radioactive decay, and for his overall performance he was awarded the Queen Victoria Scholarship to study overseas. His teachers advised him that the best place to study physics would be Cambridge, but his scholarship would not have allowed him to cover three years at Cambridge. London was also considered as a good possibility. He then learnt that Germany was relatively cheap compared with England and that German universities had a high reputation for science. As he was advised that his knowledge of German was adequate to allow him to follow lectures without difficulty he eventually decided, with the help of his teachers, to choose Göttingen University. This had a highly distinguished international reputation in mathematics and physics, and Göttingen had the merit of being a small town. He spent a year as a demonstrator at Rhodes to amplify his funds, before transferring to Göttingen in 1931.

#### THE GÖTTINGEN PERIOD

The relatively short period spent in Göttingen provided a turning point in Moses Blackman's career, and was to have a major influence on his approach to science for the rest of his life. It was the first occasion that he had been away from home on his own, and he found the country and the language completely strange. When he arrived at the end of March 1931 it was a rather cold, grey climate and the cobbled streets of the little German city had a medieval aspect so very different from a small South African town such as that to which he was accustomed. He found, however, that he could make himself understood and that he was able to follow lectures at least. The fast speed in normal speech took him about six months to get used to, but after that he could speak German fluently and readily conduct conversations with his fellow students.

Typical of the modesty that he demonstrated throughout his life, he had no exaggerated opinion of his abilities at this stage and he developed the clear view that students who were a good deal junior to himself were far better prepared for the lectures than he was. On his arrival he had no other intention than to learn by attending lectures in mathematics and physics. His views changed after a while, and it took him well over a year before he plucked up enough courage to ask Professor M. Born to take him on as a research student. He had attended lectures on statistical mechanics and quantum mechanics by Born, as well as seminars and colloquia, and had developed a healthy respect for him as well as interest in the subjects. He believed that Born did not have a high opinion of him at the time, but Born had been asked by Professor Pohl to suggest an explanation of a phenomenon that had been found in his, Pohl's, laboratory, and so Blackman was eventually given the task of tackling the

problem. It was concerned with anomalous features of the wavelength dependence of the reflection of infrared radiation by ionic crystals, whereby subsidiary maxima were observed in addition to the expected main maximum in the neighbourhood of the characteristic frequency. Born introduced him to lattice dynamics, and showed him how the optical constants of the ionic linear chain could be calculated by a method devised by Peierls in another connection. By March 1933, when Blackman had completed what he had regarded as the first stage of his research, Hitler came to power in Germany and many university professors, including Born, were dismissed for racial reasons. Blackman was advised to write up what he had done, as a D.Phil. thesis, and, as Born had departed for Italy, the thesis was examined by Heisenberg, as external examiner. Although Blackman believed that all concerned took a lenient view because of the circumstances, he was awarded the D.Phil. degree with the designation 'sehr guht'.

Blackman's stay at Göttingen laid the foundation for his future research work and especially his attitude of mind towards research. The experience of attending colloquia with people such as Pohl, Goldschmidt, Born, Teller, Heitler, Nordheim and others of high international reputation left a lasting impression on him. The standard of excellence demanded by scientists of such proved calibre was extremely high, and scientific work was judged at this level. Anything falling short of this was attacked mercilessly. He found the students with whom he mixed also of a high calibre, both scientifically and in general education. By the end of 1932, even though the rise of the Nazis was casting a dark shadow, the general level at Göttingen still approached the best in the European tradition of science and learning.

#### BEIT FELLOWSHIP AT IMPERIAL COLLEGE

Blackman was determined to continue his research career that had suffered such a dramatic interruption so soon after it had begun. He decided to apply for the Beit Fellowship at Imperial College, and so meet one of his earlier wishes, to study in London. As a result, he believed, of Born's help he succeeded in being awarded the Fellowship and arrived in London in 1933 to join the Mathematics Department under Professor Sidney Chapman, at the same time as a flood of refugee German scientists was arriving in England.

He found research conditions in London very different from those in Göttingen. Chapman had his own research group working on effects in the upper atmosphere, and left Blackman to determine his research programmes very much on his own. Inevitably he turned to problems that he had been turning over in his mind at Göttingen. He decided to follow up his work on the vibrational spectrum of crystals, and relate it to their heat capacity. He had talked about this to Born who had not been very

encouraging, saying 'Sie Finden alles in meinem Buch' ('You will find it all in my book'). Blackman was aware that the dynamics of crystals is dealt with in *Atomtheorie des festen zustandes* and that this led to a vibrational spectrum, but he concluded that no detailed work existed. He also felt that the literature on the subject revealed deficiencies in the Debye theory, in that there were cases where the elastic data did not fit the heat capacity data at low temperatures. He considered the whole position as rather a mess and decided to try to understand the relation of lattice theory to continuum theory (Debye theory) by determining the heat capacity in terms of the vibration of the simple linear chain. In the mean time, Born had started on the detailed lattice dynamics of ionic crystals.

Although Blackman maintained that he had not introduced any new ideas, he had, in a space of two years, developed his approaches sufficiently successfully to allow formal treatment of three-dimensional lattice problems. His linear chain treatment had led to an examination of the two-dimensional square lattice, the Born v. Kármán model, in which the vibrational spectrum contained two frequency branches, which in turn led to the understanding of the general problem. Thus the deficiencies in the Debye theory, including the inadequacy of a one parameter theory and various other aspects had all been identified and the real position had been clarified.

As a result of his two years at Imperial College, which had to end with the automatic termination of his Beit Fellowship, Blackman had made great progress in advancing lattice theory. He submitted a Ph.D. thesis, and so received a second doctorate after no more than four years of research.

#### THE PERIOD AT CAMBRIDGE

By 1935 he was in a much stronger position to achieve the goal that had first been put to him in Rhodes, to study physics at Cambridge.

He succeeded in obtaining a Department of Scientific and Industrial Research Senior Research Award, which supported him for a further two years and allowed him to register for yet a third doctorate. He was able to examine in detail the three-dimensional Born v. Kármán cubic lattice while he was in Cambridge. He chose a case that allowed progress with the minimum of numerical work, but it did lead to the determination of the first vibrational spectrum for a three-dimensional lattice. He was able to apply this spectrum to the Debye-Waller theory for X-ray scattering from crystals, which had been developed to explain the occurrence of temperature-dependent diffuse X-ray scattering. He was already demonstrating his enthusiasm for being able to give rational theoretical interpretation to what he judged as reliable experimental observations on crystals. A piece of work in this class was his work on the De Haas v. Alpen

effect. This followed a suggestion by Peierls, and was stimulated by some observations made on bismuth in the Mond Laboratory in Cambridge. It involved incorporating the ideas of effective electron masses into the Peierls theory of diamagnetism, and Blackman managed to achieve the results he sought by using extremely small effective masses. This largely forgotten paper provided the foundation for some of Landau's work that subsequently stimulated many experimental and theoretical papers that now represent the basis of our understanding of the physics of conduction.

Having completed his third doctorate, and once again come to the end of his financial support, Blackman sought other opportunities. One came immediately with an invitation to him to return to Imperial College, this time to the Physics Department.

#### RETURN TO IMPERIAL COLLEGE

Professor Sir George Thomson, the son of J. J. Thomson, had established a strong experimental group on electron diffraction when he moved to Imperial College from Aberdeen in 1931. He recognized the need to strengthen the theoretical side of the work and, learning of Blackman's achievements, he invited him to join the Department as a theoretical assistant. Thus Blackman arrived in 1937 as an assistant lecturer, and joined the electron diffraction group where he set about learning about crystal diffraction theory. For the first time he was closely associated with experimental work, which was supervised by Dr W. Cochran who, jointly with G. P. Thomson, was writing the first full textbook on electron diffraction, and he ended up being largely responsible for the treatment of dynamical theory that was included in Thomson & Cochran's book *The theory and practice of electron diffraction*, which appeared in 1939. During that initial period he applied the dynamical theory to the calculation of the widths and the intensities of rings formed by electron diffraction from polycrystals.

A change of a different kind came after he had spent about two years with the electron diffraction group—World War II began. Research activities on electron diffraction were wound down and largely stopped for the duration of the war. In the early part of the war Blackman continued with his own work on the lattice theory of specific heats, publishing several more papers, but like many others he was drawn into the war effort. However, in the course of only a few years he had succeeded in publishing a number of important papers, which had opened new areas of solid-state physics.

Soon after his arrival in the Physics Department, Blackman became acknowledged as the theoretical physicist of the Department. For the next 15 years or so he was liable to be asked for advice on any theoretical or mathematical topic. He was always most helpful and penetrating, being prepared to give of his time with generosity and to give a carefully

considered answer to questions raised with him. It was not uncommon to find him returning a day or two after a question had been posed, and already partly answered on the spot, with two or three sheets of paper covered with mathematics and perhaps a graph or two, outlining his more considered and detailed answer.

#### THE BRITISH COMMITTEE ON ATOMIC ENERGY

In the late 1930s G. P. Thomson had become actively involved in the earliest attempt to investigate the possibility of achieving a sustained chain reaction of fission of uranium by neutrons. He organized the delivery of one tonne of uranium-containing ore to Imperial College Physics Department, and extensive measurements were made of the neutron multiplication factor. Several people became involved in this work, with the bulk of the measurements being carried out by J. L. Michiels. Blackman contributed to these efforts by theoretical calculations concerned with the neutron diffusion process, and because of his involvement and his understanding he was appointed to serve on the British Committee on Atomic Energy during 1940 and 1941.

#### WORK FOR THE MINISTRY OF HOME SECURITY

Between 1942 and 1945 Blackman carried out various pieces of scientific work for the Ministry of Home Security. The most extensive of these, and the one that led to three postwar scientific publications, concerned the properties of foams used in fire-fighting. Various aspects were investigated, including the way in which the gas phase is dispersed in the foam, the transmission of light through the foam and the effect of an applied shear on the behaviour of a foam. The scientific aspects of the work were carried out in collaboration with the Chemical Research Laboratory at Teddington, where N. O. Clark was the scientist mainly involved. Some of the more applied aspects, which were never described in the open literature, involved collaboration with W. G. Penney, a former member of staff of the Mathematics Department at Imperial College and later to become Lord Penney and Rector of Imperial College. Although Blackman's contributions to the work on foams were mainly of a theoretical and mathematical kind, as might have been expected, he did come into close contact with some extensive laboratory experimental work, and even exercises of a more practical kind in connection with trials on the applications of foams. One of his solo author papers was a brief account of experimental work, for which he acknowledged a Mr E. V. Nehan for assistance in the carrying out of the experiments.



## WORK ON THERMONUCLEAR REACTIONS

Immediately after the end of the war G. P. Thomson became enthusiastic about achieving controlled thermonuclear reactions. Stimulated by the technical success that had been obtained in the building of the atomic pile, he was already looking ahead to the possibility that nuclear fusion reactions in light elements could be used for power generation. Thus he initiated some work to explore whether fusion reactions could be produced by means of a gas discharge in a toroidal vessel. As on previous occasions he realized the need to involve a theoretical physicist, and once again turned to Blackman, a man he could trust and for whom he had great respect. They worked together with great energy, and by May 1946 they filed the first provisional patent on the subject of controlled thermonuclear reactions. The complete specification followed in just under the 12 months.

Experimental work aimed at demonstrating the realism of the proposals was started in the Physics Department in 1946, carried out by A. A. Ware. This work on the toroidal gas discharge tube was aimed at demonstrating the production of neutrons by, for example, the fusion of two deuterium ions. It required that electrons produced in the ionized gas circulate at high speed and, with the associated magnetic fields, cause the positive nuclei of the gas to be contained in a narrow cross section closed loop remote from the vessel walls. Blackman played a key role in carrying out extensive theoretical studies of the factors that could cause the confinement of the ionized gas current, by the pinch effect, and undoubtedly did much to maintain real impetus behind the project.

The work was supported by the United Kingdom Atomic Energy Authority, and it soon became clear that it would not be possible to continue the work in a university department, for reasons of security. A parallel effort had already started at the Atomic Energy Research Establishment at Harwell, but to maintain an independent project G. P. Thomson succeeded in arranging that Ware's activities be transferred to the A.E.I. Research Laboratory at Aldermaston, where it continued for some years, with both Thomson and Blackman maintaining their involvement. They submitted a second patent application in 1952, and the complete specification was filed in both Britain and the U.S.A. in 1953. The only publication from this early work was a paper by Blackman on the theory of the pinch effect.

The experimental work did not succeed in its aims, and eventually all British efforts were concentrated at Harwell with the result that Thomson's and Blackman's involvement came to an end. When, eventually, the Harwell team announced the 'success' with their ZETA experiments, Blackman was convinced that the claim was invalid. His opinion was based upon a deep and detailed understanding of what was involved. Time proved his scepticism to be justified. However, Thomson

and Blackman must be given the credit for their far-sighted very early pioneering work in a field that has now become of major international importance but that has still to achieve the real breakthrough, which is being sought with the help of such relatively massive resources.

A parallel and related research effort started by G. P. Thomson at about the same time as the work with the toroidal gas discharge was concerned with the design of an air cored betatron. This was carried out primarily by R. Latham and M. J. Pentz, but Blackman was also involved with theoretical design aspects and was a co-author of the only publication. The equipment was never taken beyond the stage of a prototype for design feasibility studies.

#### THE POSTWAR ELECTRON DIFFRACTION GROUP

Once the war had ended the electron diffraction work was recommenced in the Department. The first research project was carried out by a Polish student, J. Skrebowski, who built a low-temperature electron diffraction camera for studying the diffuse patterns observed on electron diffraction photographs from organic crystals such as anthracene. Blackman took a close interest in this work, which he had stimulated because of his previous involvement in the equivalent X-ray diffuse scattering and its dependence upon lattice vibrations. The phenomenon had already been studied by the rival electron diffraction group in Imperial College, that headed by Professor G. I. Finch in the Department of Chemical Technology, and there were strong disagreements between the two groups on the interpretation. Skrebowski presented a paper on his results at a meeting of the Physical Society held in the Autumn of 1947, when the arguments became quite heated. Unfortunately Blackman was unable to be present to support Skrebowski, because he had gone to South Africa during the summer of 1947 to visit his family and had contracted malaria. Consequently he was unable to return to Imperial College until 1948, by which time Skrebowski had departed and two new research students, V. F. G. Tull and D. W. Pashley, had begun.

For a few years both G. P. Thomson and Cochrane were playing an active part in supervising the work, with Blackman taking a very close interest, in addition to his other major activity concerned with thermonuclear reactions. His enthusiasm and curiosity had a stimulating influence on progress at that time. He provided valuable guidance through his deep and thorough understanding of both crystal physics and the diffraction of electrons. He also demonstrated a keen appreciation of experimental aspects of the work, notably the design of experiments and their interpretation. To many outside those closely involved with him he was a devoted theoretical physicist with little or no contact with, or feel for, experimental work. Nevertheless he became head of the electron diffraction group in 1952, when both Thomson and Cochrane had left the

Department, and so he was then responsible for a research activity that was primarily experimental. In fact, he would have enjoyed the prospect of doing some experimental work himself, but felt that he did not have adequate manual dexterity to make it worthwhile. We shall never know whether this was just part of his natural modesty! What is certain is that he was able to make a more valuable contribution to experimental work by the strong guidance he was able to give to a sequence of research students and other research colleagues.

During the 1950s, when it started to become less customary to address colleagues by their surname, Blackman became known as Morris, a name that he seemed most happy to adopt. Also, in 1959, Morris Blackman married Anne Olivia, the daughter of Arthur L. Court of Sydney, Australia. The marriage was terminated a few years later, although Morris and Anne remained on friendly terms right up to Morris's death.

Under Blackman's leadership the electron diffraction group flourished for many years, and a total of about 20 research students completed doctorates between 1949 and 1977. One of the initial areas of interest, worked on by Tull, was concerned with measurements of the inner potential of crystals by measurement of refractive indices, with electrons entering crystals at grazing angles of incidence. The other area was concerned with oriented crystal overgrowths, or epitaxy. This topic was one that Thomson had introduced earlier because reflection high-energy electron diffraction, which became known as RHEED many years later, seemed to provide a powerful new technique for investigating the very early stages of the formation of oriented overgrowths. Morris Blackman was most fascinated by the fact that oriented overgrowths could occur with large lattice misfits between substrate and overgrowth, so that to supplement the experimental work being done by Pashley, and soon after also by L. N. D. Lucas from Australia, he started another research student, M. Smollett, to do some theoretical work on the stability of the monolayers that could initiate the formation of an oriented overgrowth. He was highly sceptical of the theory of oriented overgrowths that was introduced by Frank and van der Merwe in 1949, because this theory only explained epitaxy occurring below certain limiting misfits. This scepticism stimulated a great deal of new experimental work on the topic, which included some of the first attempts at making systematic and sequential studies of deposits grown on crystals inside an electron diffraction camera.

This kind of experiment required new equipment, because for the first few years after the war the group had had to make the best of old prewar electron diffraction cameras that still used rather unstable gas discharge electron guns and poor and dirty vacuum systems. New equipment was built in the early 1950s by two new research students, R. B. Kehoe and R. C. Newman, with Pashley. Although it overcame many of the deficiencies of the earlier equipment, it still suffered from a relatively dirty vacuum system operating at not much better than  $10^{-5}$  torr. At that time

the electron microscope was developing rapidly and there seemed to be opportunities for it to provide more useful information on crystal growth. G. P. Thomson had, in fact, been encouraged to seek funds for an electron microscope to strengthen the experimental studies of epitaxy, and although he had succeeded in doing so he left the Department to become Master of Corpus Christi College in Cambridge, before the microscope could be delivered. By the time it was available for delivery P. M. S. Blackett had become Head of Department and it was left to Blackman to re-affirm the need for the microscope. He was unwilling to take responsibility for it, largely because he felt that there would be insufficient effort available to keep such a piece of equipment operating effectively. He was wary of acquiring a white elephant. Those of us on the experimental side at the time were much disappointed by the decision. I had already attended a summer school on electron microscopy in readiness. However, in retrospect, this was probably a sound decision even though subsequent developments showed that electron microscopy had much to offer, because far superior microscopes became available within a relatively few years. Fortunately for the group an electron microscope was obtained, with Blackman's full support, in 1961.

Morris Blackman developed a strong interest in the diffraction that occurs from bent or curved crystal lattices, because thin electron diffraction specimens commonly suffer from bending. To demonstrate the significance of a theory that he produced, it was necessary to plot intensity profiles in reciprocal space, in the region of the main reciprocal lattice points. This involved numerical integration and evaluation of an expression containing many terms, for a range of different values of the main variable parameters. It is illustrative of his strong devotion and dedication to his research that Blackman spent several weeks during the 1950 summer vacation on this task, which he carried out by using 5-figure logarithms. The tabulated calculations covered many pages of closely spaced columns of figures, and provided just three graphs revealing the form of the intensity function close to three reciprocal lattice points. The driving force for his efforts was the enthusiasm that he had to achieve some advance in understanding, and such achievements always gave him great pleasure and excited satisfaction.

The basic scattering processes of electrons by crystals continued to arouse Blackman's interest, and he was always puzzled by a pattern of Kikuchi lines that had been obtained by H. Boersch, and that had been reproduced in the book by Thomson & Cochrane. This seemed to indicate that relatively large numbers of electrons could be scattered through large angles, up to about 160 degrees, without large losses of energy. This stimulated him to put a new Pakistani research student, M. N. Alam, on to the problem of investigating the formation of high-angle Kikuchi lines. A special camera was built for the purpose and this provided a great deal of new quantitative information, with various alkali halide crystals being

used as specimens. The formation of well defined Kikuchi lines at high angles of scattering was indeed confirmed, and such patterns have subsequently been employed to good effect by other workers, in suitably modified scanning electron microscopes, to provide useful crystallographic information about specimens.

A chance observation with a cobalt crystal, by another research student, E. Grünbaum, led to a new area of work concerned with revealing magnetic domain structure by means of electron beam shadow images. Characteristically, Morris Blackman exhibited healthy scepticism of the suggested magnetic origin of the usual shadow images when they were first drawn to his attention by Grünbaum, which is not surprising because they could easily have been confused with effects often observed with specimens susceptible to charging up in the electron beam. However, a few experiments soon confirmed the magnetic origin, and from then onwards he poured his enthusiasm into this new opportunity and a new area of work was born. The resulting interest that Morris Blackman developed in magnetic materials was to stimulate some further new research many years later (see the section on lodestones). More immediately, the technique was applied to the study of magnetic transformations in magnetite and haematite. This involved cooperation with Professor Blackett's group working on studies of continental drift by mapping out directions of magnetization of rocks in different points in the Earth's crust. Blackett, later to become President of the Royal Society, agreed to one of his research workers, G. Haigh, joining with Blackman's group in the exploitation of the technique, which proved very fruitful.

Interest in crystal growth and epitaxy resulted in an area of collaboration with the Meteorology Department. Dr B. J. Mason, later to become Treasurer of the Royal Society, was much concerned with the mechanism by which clouds could be seeded to produce rain, and because there was some evidence to suggest that silver iodide is effective as a seed, a collaborative effort was initiated to study the growth of ice on silver iodide. This required work with a low-temperature stage in the electron diffraction camera, and resulted in new information on the crystallographic structural forms of ice. This field of work, coupled with subsequent electron microscope studies of thin metal deposits in the form of fine particles, stimulated Blackman's interest in the effect of particle size on melting point. As a result he encouraged work on melting and superheating, and a succession of papers appeared on these topics.

Once the expansion of Imperial College started in the mid 1950s there became scope for increasing the academic staff in the electron diffraction group, and in 1957 Dr N. D. Lisgarten, who had been brought in initially to carry out the research on the ice project, was appointed a lecturer. This was followed a few years later by the appointment of Dr A. E. Curzon who had initiated the experimental work on the melting point of small particles. Consequently Blackman was able to ensure that he had strong

support on the experimental side in continuing to run an active group. Although he still made contributions to lattice theory from time to time, especially in relation to thermal expansion, most of his efforts were devoted to the electron diffraction group right up to his retirement in 1976. Curzon left the group in the late 1960s, to take a post in Canada, and he was replaced as lecturer by Dr P. J. Dobson, who remained with the group until after Blackman's death.

Blackman himself received recognition by Imperial College when he was appointed to a personal chair in electron physics in 1959. This was followed by election to the Fellowship of the Royal Society in 1962.

#### WORK ON LODESTONES

Immediately after his retirement in 1976 Blackman was given the appointment of Senior Research Fellow, which meant that he was able to maintain membership of the Physics Department and continue to be involved with research. He chose not to participate strongly in the activities of the electron diffraction group, which continued under Dobson and Lisgarten.

Blackman had developed strong interests in magnetism, and in discussions with Professor E. P. Wohlfarth of the Department of Mathematics the idea emerged that there was scope for obtaining a better understanding of the origin of the magnetism of lodestones, some of which were reported as having extraordinarily high intensities of magnetization. In addition to a great deal of searching of the literature, some of which originated in the 17th century, it was necessary to carry out some careful magnetic measurements on lodestones, many of which were obtained from museums. Lisgarten, who had already worked closely with Blackman for more than 30 years, took it upon himself to help Blackman in this work. There followed several years of painstaking but rewarding work. Blackman continued to devote most of his time to his research, and he tackled the lodestone problem with the enthusiasm of a schoolboy. Being relieved of any responsibility for others, and having no teaching duties, meant that he could devote all his intellectual energy to the lodestone work. He lived for his research, and seemed to enjoy it immensely.

His health had been failing, but he always seemed to manage to pull round and recover from several low points. When he died suddenly on 3 June 1983, it was only a few weeks after his final and comprehensive paper on lodestones had been published. All of his close friends and colleagues were very thankful that he lived long enough both to complete the work for this paper and to see it appear in print. It was a fitting end to a man whose whole working life had been devoted to physics, and who always experienced excitement when either he or one of his colleagues achieved some advance in scientific understanding.

## CONCLUDING COMMENTS

To his long-standing colleagues at Imperial College Morris Blackman was a familiar figure. Small, almost always wearing a dark loose suit, he would be ready for a chat about anything and enjoyed the company of his colleagues. He was a kind and patient man, not given to boasting, who could talk with anybody, young and old. In his earlier years at the College he would frequently be found in the lunch hour playing table tennis, and his pleasure in interacting with others, both staff and students alike, was obvious. After his retirement he regarded the Senior Common Room as his club, and for someone who lived alone this was an important part of his life. To many of his friends and colleagues who knew him over many years and who were with him to within a few hours of his death, his passing was a sad blow. Somehow it seemed unreasonable that he would not be in his 'club' for lunch ever again.

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The photograph reproduced was taken in 1962 by Walter Bird.

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