

1 © *W. Sillitto 2007*

**Dick Sillitto's involvement with Physics,
1940-2005**

compiled by Winifred Sillitto, October 2006 – April 2007

Richard M. Sillitto, BSc, FInstP, FRSE, FellowOSA

In his last year at Dumfries Academy 17-year-old Dick Sillitto was enthralled by a course on simple harmonic motion, given by an enthusiastic maths teacher. Then, as an undergraduate in the Natural Philosophy department of Edinburgh University, he found the same excitement in the mathematical physics lectures of Tait Professor Max Born. Born's exams would not be approved nowadays; "you always learnt something new from them" Dick would recall in later years. The pass mark could be lower than 30%, and only one of his fellow students, Ian *(W S) Cassells*, ever achieved the first-class 90s. Dick's talents lay rather in the physics of Professor Barkla's department, and particularly in the Optics laboratory of 'daddy Milne'. In those days both departments were housed in the 1853 hospital building between Drummond Street and High School Yards.

In 1943, at the end of 3 years' study, Dick was offered a job by Barkla but his call-up for war service could not be delayed. Directed to the Admiralty Signals Establishment in Lythe Hill House, Haslemere, he worked in a team designing and testing infra-red signalling devices. His immediate boss was Donald McGill who later had a major influence on the way physics was taught in Scotland's schools. It was a stimulating environment, involving contact with many excellent scientists, engineers and mathematicians, naval officers and industrial representatives. A memorable few weeks occurred for Dick when he worked in Witley with Gold, Bondi and Hoyle on a project using optical techniques for detecting targets in noisy radar displays (a visit to Gold's – or was it Bondi's? – flat in Lubetkin's Highpoint in London may be to blame for Dick's later interest in modern architecture). Another mind-blowing experience was reading the collected works of Augustin Fresnel – and finding that all the clever optics which he and his colleague Eric Stanley had discovered, had already been thought of by Fresnel.

Dick's skills impressed the industrialists he met, and in the summer of 1946 he was persuaded to consider employment with optical instrument and glass manufacturers, Chance Bros of Birmingham. However, when it was discovered that he was only 23 years old, he was told that he was not eligible for the salary that went with the job in mind. Instead, he decided to return to Edinburgh to convert his unclassified War Regulations Honours degree to a classified one. But Norman Feather, Barkla's successor as Professor of Natural Philosophy, suggested that he start straight in on a PhD, and this he did in October 1946. The proposed topic was a search for the Kapitza-Dirac effect, a predicted diffraction of free electrons by a spatially periodic light field. It soon became clear that the available technology was still inadequate, and the project was abandoned.

During this year Dick supplemented his income by teaching an evening class in the Heriot Watt College, in Chambers Street, where W H J Childs was Professor of Physics. He also attended an evening class in Workshop Practice there; as a result he was one of the few academics who were allowed to use the machines in the Edinburgh University physics workshop. Between whiles he was thinking deeply about the fundamentals of quantum mechanics in response to questions raised by his fiancée as she studied for her honours degree in Experimental Physics at Queen's University, Belfast, where K G Emelús was professor.

In September 1947 Dick and Winifred were married, almost 3 years after their first meeting in Haslemere, and in October Dick was appointed Assistant in the Edinburgh Department of Natural Philosophy, with responsibility for the honours optics laboratory and many tutorial duties.

1.1 1948-1958: Acoustics

A year later, he was appointed to a lectureship. It was a period when many of the undergraduates he taught had served in the Forces during the war. At least one of them still remembers his disgust at being taught by someone who had been a fellow student earlier in the decade. Most interesting and enthusiastic were the Music students to whom Dick lectured on acoustics; one of them had run a radio station for the Allied Forces in Germany while another had played on some famous Baroque organs. An amusing by-product of this was the invitation to give a talk on musical temperament to accompany a recital on the newly created McClure organ. Presided over by Professor of Music, Sidney Newman, this was part of the 1951 meeting of the *British Association for the Advancement of Science*, a meeting for which Dick was one of the local secretaries along with John McPherson and Robert Taubman from the University Administration.

In March 1952 a 15-minute BBC Home Service broadcast began:

In tonight's *Science Review* R.M. Sillitto discusses the latest attempt to construct an organ which will play harmoniously in any key. This is the McClure Organ at present in the University of Edinburgh.

Illustrations were played by Herrick Bunney, some on the St Giles organ, some on the McClure. Two BBC pianos were used by Dick, one of them 'mistuned' under his guidance, to 'just temperament' for the key of C, the other in standard equal temperament. The broadcast was repeated in response to listeners' requests, and was broadcast in the BBC Overseas Service.

A young English composer, John Buckland, composed a *Pièta* making use of the organ's microtones and sent it to Dick. Other musicians got in touch, particularly during the Edinburgh Festival, and Dick showed them the special features of the organ. Father Laurence Bévenot of the Priory, Workington, started a lengthy correspondence during which Dick analysed Dr. McClure's notes and tuning instructions to determine precisely the temperament to which the organ was tuned.

In May, 1952, an audience of about 80, including some Edinburgh organists, attended a public lecture which Dick gave under the auspices of the Edinburgh University Physical Society. Illustrations included recordings made on the McClure organ by student Kenneth Greenway. The following February a lecture to the Scientific Society of the University College of Dundee, on the development of tempered scales, attracted an audience of nearly 100. These lectures were illustrated by recordings of Herrick Bunney and the Edinburgh University

Singers – superbly made for the BBC record library by BBC engineers led by John Robertson (who famously wrote a Scottish country dance, *The Duke and Duchess of Edinburgh*) for use in a half-hour talk on the Third Programme in November, 1952. This programme was faded out to the strains of *Prelude and 4 Chorales* by John Buckland. Then requests came from physicists in Nottingham and Manchester, asking for copies of the musical recordings. A. Maxwell wrote, from Jodrell Bank,

I listened to your Third Programme talk last November with considerable interest, but (with the greatest of respect to Mr Buckland) the music specially written for the Edinburgh organ, with its sprinkling of D sharps and E flats was almost more than my ears could bear!

In January 1953, Dick took part in a 13-minute broadcast for schoolchildren, *Making Sounds*. BBC Scotland producer Harry Hoggan wrote “There have been some very good reports about your last Nature Study broadcast which was not an easy one for these young children, but I thought the final show came off very well.” Dick’s 12-year-old niece had a very different opinion. Indeed the rehearsed and pre-scripted alternation of demonstration and question made for a ‘Listen with Mother’ delivery which was not really Dick’s style. In April, however, at the annual meeting of the Science Masters’ Association Scottish Branch, Dick

“gave an excellent lecture-demonstration on *Sound in Schools*, with special reference to the new Scottish Leaving Certificate syllabus. His demonstrations covered every aspect of the syllabus, and were highly suitable for a school course. He ended by asking that school pupils should be trained in the habit of precise quantitative thinking, which was far more valuable as a basis for university work than mere factual knowledge.”

An earlier request for acoustical investigation came from Stuart Piggott, Professor of Prehistoric Archaeology. An ancient bronze horn, apocryphally linked to Old King Cole and found in Caprington, Ayrshire, in the late nineteenth century, had been lent to the National Museum of Antiquities in early 1950 so that a replica could be made for exhibition there. Dick recorded the waveforms it produced, and also those of the replica – which were quite different. When the horn was returned for the Edinburgh Festival, the Museum’s Keeper, Robert B K Stevenson, made careful measurements which Dick used for his report at the end of the year. Dick greatly appreciated the advice he received from Marion Ross who was still teaching the building acoustics course; she had pioneered the course for music students as a young lecturer in Professor Barkla’s department, and during the war worked at Rosyth on underwater acoustics before returning to Edinburgh to pursue her own research.

Some of Dick’s work on the horn was done with apparatus in the department of Linguistics, and members of that department, Betsy Uldall, professor David Abercrombie, and technician ‘Tony’ Anthony, often consulted Dick in the ensuing decade. With Betsy he “offered a great deal of helpful criticism” to Peter Ladefoged about his 1957 thesis on the perception of vowel sounds. The teach-

ing of musical acoustics in the physics department later passed to Bob Galloway and subsequently to Murray Campbell. Many years later Murray, with Clive Greated, set up an excellent acoustics laboratory within the James Clerk Maxwell building.

1.2 1948 - 1958: Colleagues; students; book on quantum mechanics

Meanwhile Dick had joined Jack Dainty's group, working on the recently purchased Cockcroft-Walton high voltage accelerator. When Jack moved to Kings Buildings in 1951 to combine interests in nuclear physics and botany, Dick took over the running of the H T lab and supervision of the research students working there on the structure of light nuclei. Perhaps unwisely, he would not put his name on published papers unless he felt that he had done a substantial part of the work – advice, ideas and technical fault-finding did not count – and he insisted that authors be listed in alphabetical order, so his citations were meagre.

Among his teaching commitments he got great satisfaction from working with Michael Smyth, a young lecturer in the Astronomy department, to devise an Astrophysics option for Honours students. This would include the course on quantum mechanics which Dick gave for many years and which astronomer Mary Brück has called “that almost legendary course”.

Of all Dick's dozen colleagues in the Natural Philosophy department at that time, by far the most congenial was E G Dymond. Gil had worked on electron scattering in Göttingen, Princeton and Cambridge in the heady days of the 1920s, before coming to Edinburgh as a Carnegie teaching fellow. He took part in the 1937 Wordie expedition to the Arctic, to measure high altitude cosmic radiation near the north geomagnetic pole. Incidental discovery of unexpectedly low wind speeds in the arctic air led to collaboration with the department's meteorologist, James Paton. A decade later one of Gil's radio-sondes, launched in South Queensferry at sunrise, sparked a rumour of flying saucers, much to the amusement of his colleagues. When Gil died suddenly on 26 October 1952, Dick was devastated.

His sense of academic isolation was mitigated by his friendship with Emil Wolf who had come to Edinburgh the previous year to help Max Born translate and update his book, *Optik*. During his post-doctoral work on diffraction theory in the Cambridge University Observatory, Emil had travelled frequently to London to attend meetings of the Optical Group of the British Physical Society. There, he met Dennis Gabor whose ideas on optical coherence and wavefront reconstruction (holography) were to be incorporated in Born's book (see Dick's review of the 7th edition). Emil was only in Edinburgh for a little over 2 years, until shortly after Born retired, but Dick spent many happy evenings with him, discussing Gabor's ideas and Emil's discovery that a satisfactory theory of optics could be based on observable quantities – new insights that influenced some of the experiments Dick devised for the honours laboratory.

Throughout his life, Dick felt that he owed the world a living. In return for his salary he felt his primary obligation was to the students; his own research was an enjoyable adjunct, necessary to keep his teaching alive. His lectures were always freshly thought out, spiced by appropriate demonstrations supported by Mr Thomson who looked after the department's historic collection of apparatus. The tradition of taking the Honours students to *The Burn* for a week of intensive study, walking, talking and 'gracious living' was started by Dick in September 1952. Most of the ex-servicemen had by now completed their studies, and these much younger students had little experience of life beyond school and university. Outstanding among this first group was Enid MacRobbie. She stayed at Edinburgh after graduating and became the first graduate student in Jack Dainty's new biophysics research group. Her subsequent career in Cambridge is legendary, as is that of Archie Howie who, with Tom Kibble, was in the cohort which graduated in 1956. Dick's lectures on quantum mechanics came after a rather mathematical course on wave mechanics by Jim Hughes, and Dick's informal style gave the students confidence to ask questions; these always got very careful consideration. Archie Howie remembers that about half of one lecture was devoted to dealing with a question raised the previous day. Others remember "a young enthusiastic lecturer with a lovely sense of humour and a real understanding of the difficulties we students had in understanding some aspects of physics".

It was not surprising, then, that Dick decided to write a book on the subject. *Non-Relativistic Quantum Mechanics – an introduction* was largely written during the mornings of July, 1958, and was published in 1960. It was the first Edinburgh University Press textbook to make a profit. A subsequent tempting offer from another publisher, for a more elementary book, had to be turned down since Archie Turnbull of the EUP, backed up by Principal Sir Edward Appleton, argued that it would be using work done for the first book. The revised 2nd edition of NRQM came out seven years later, with a topical appendix on the density matrix. As a student of English, Archie had been one of a group with whom Dick had 'hung out' in his own student days, sitting on the grass which then enhanced the Old Quad; he joined the Lovat Scouts, and came back to Edinburgh after the war to proof-read *Chambers Dictionary*, and even add some beguiling entries.

1.3 1956 - 1966: Public lectures; Director of Studies; coherence optics

Dick was frequently called upon to give talks to non-specialist audiences – senior schoolchildren, the students' Physical Society, members of the IOP. Perhaps the most memorable was about Maskelyne's experiment on Schiehallion in 1774 to 'weigh the earth', a topic of interest in the International Geophysical Year, 1957, revisited in the early 60s and again in 1990. That 1990 text can be seen on the internet, illustrated with photographs taken by Michael Smyth in 1962. Michael had initially come to Edinburgh in 1950 when Astronomer Royal W M H Greaves was professor of the new university department of Astronomy. In 1957 Michael went to Dunsink Observatory, which Hermann Brück had just left to come to

Edinburgh following the death of Greaves. A few years later Michael returned to Edinburgh.

In 1959 Dick gave an address as past Chairman Arthur Brown was now Chairman) of the Scottish branch of the Institute of Physics. This was published in 1960 in the Institute's Bulletin under the title *Light waves, radio waves and photons*. In it Dick discussed two remarkable experiments of the mid 1950s – one by Hanbury Brown and Twiss, working at Jodrell Bank; and the other by Forrester, Gudmundsen and Johnson, in USA. Both could be interpreted, up to a point, in terms of coherence, but attempts to understand them in terms of the crude popular model of a beam of light – as a stream of discrete indivisible corpuscular photons – generated vigorous controversy. The use of fast photoelectric detectors was crucial to both experiments, and Dick had contributed to the discussion with a short paper which happened to attract the attention of a refugee from Hungary, Peter Farago. Later that year, 1957, Peter was appointed to a senior lectureship in the department. At last Dick had a colleague, five years his senior, with similar interests. Peter has written

“Soon after I had settled down to my job, I moved in to share Mr. Sillitto's office. It was only a few years later that we acquired ‘private’ offices next door to one another and we continued to live in an ‘entangled state’ of co-operation both in teaching and in research, activities which were very closely coupled. To return to the paper in question: it was about a very ‘hot’ topic of the time: *Correlation between events in photon detectors...* The phenomenon usually referred to as the ‘Hanbury Twiss effect’ had recently been experimentally established, but was somewhat controversial (apparently at variance with a dictum of Dirac's) and understood by only a few. Dick understood it, and I was taught about it by him.”

About the same time, the illness and death of 61-year-old Bernard Childs in July 1956 precipitated Dick into a stint as Director of Studies. He was somewhat surprised to discover that some of his ‘clients’ were doing physics only because of parental pressure and had no heart for it. After his interview with Dick, one of them left and joined the Black Watch band. Francis Barnes, Richard Dougal and David Vass, later to be members of staff, were among the more enthusiastic first-year students.

Routine white blood cell counts for those who worked with the Cockcroft-Walton machine during these years were causing concern about Dick. He was examined frequently in the respiratory diseases clinic because beryllium poisoning was suspected. However, there were no other symptoms apart from intermittent fatigue, and the diagnosis seems to have been based simply on the fact that beryllium was being used in Bob Galloway's PhD project. Dick was diagnosed with diabetes in 1964, a period when the relevant dietary advice included (unfortunately) “butter and cream – as much as you like”. Shortly afterwards he flew to New York to attend a conference in Rochester, where Emil was now established, and was bewildered when his emergency snack, an orange, was confiscated at Kennedy airport.

By 1961 Dick was a Fellow of the Institute of Physics and of the Royal Society of Edinburgh. He was granted his first and last sabbatical leave, for one term, with a view to spending more time on the new problems in optics. He continued in charge of the HT lab until 1963 and to supervise nuclear physics students until 1966 when George Bradford and David Vass had completed their PhDs. He used his leave to visit, with Peter Farago and Peter Kennedy, various university and government laboratories, making contacts in the National Physical Laboratory and the establishment in Malvern which had developed radar during the war and whose name has changed many times since. Back in Edinburgh he applied methods used in the mathematical analysis of random noise to show that, with the then available circuit techniques, it should be possible to observe interference between beams of incoherent light from sources whose line widths are comparable with those of the Hg-198 electrodeless discharge. In 1962 he was promoted to Senior Lecturer, and Feather encouraged him to proceed with such an experiment, an extension of the Hanbury Brown Twiss classic. Farago's former colleague Zoltán Bay suggested using a Fresnel biprism (a prism whose vertex angle is nearly 180 degrees) to create two closely spaced virtual replicas of each of the two incoherent sources. No interference fringes would be visible, but coincidence rates should show a periodic variation as one photodetector is moved relative to another across the uniformly illuminated field.

Nigel Haig, who graduated in 1963, tackled this as part of his PhD studies. Although a sufficiently accurate biprism could not be obtained, a modified experiment was begun in July 1967 using instead a second double slit. Complete success would have required observing times of 369,000 seconds, but by September fluctuations in the ambient temperature of the laboratory forced an early conclusion with only 102,000 seconds at each position. Statistically significant results had however been obtained and further counting would not have improved the statistics. The multitude of practical problems associated with stabilising and optimising this equipment and the fast (for the time) coincidence circuitry provided a training which stood Nigel in good stead in his subsequent inventive career at RARDE. Of Dick he writes

“it was his great gift of thinking logically and with clarity about ‘ordinary Physics’, the tuning fork, for example, that drew my admiration more than his remarkable facility with the theory of quantum mechanics. . . .

. . . Dick's approach to physical problems impressed me enormously, and has helped me by teaching me to challenge the apparently obvious, and showing that things may not be quite so obvious after all. It is the way of thinking, rather than the straightforward data manipulation, that I found so useful in my later research.”

In 1966 Dick had published a paper in *American Journal of Physics* showing that the intensity variation in sound from a rotated tuning fork was due to quadrupole, not dipole, radiation. Another topic he tackled was the treatment of the children's swing as a parametric oscillator - very relevant to topics in optics which had arisen since the invention of the laser in 1960.

Lasers were objects of great interest in those days. In January 1964 Dick used one when he talked on *Waves* in the fortnightly series of illustrated evening

lectures at the Royal Scottish Museum in Chambers Street. That afternoon he had given the Christmas Lecture for senior schoolchildren there, repeated in Paisley the following week. In a letter two days later Dick wrote:

Dear Mr Chilcott,

I want to thank you very much, both from myself and from the Institute of Physics, for enabling me to demonstrate the Ferranti helium neon laser at the lectures I have been giving recently under the Institute's auspices. Will you please pass on my thanks also to Dr Clark and Mr Forbes.

I made the demonstration the climax of my lectures – the title was “Waves” and the operation of the laser seems to me the most complete demonstration possible of the wave nature of light – and it so fired the imagination of the audiences that it was the thing that everyone crowded round at the end, and wanted to ask questions about.

It was made very clear in the lectures that the laser on show had been developed and loaned to me by Ferranti in Edinburgh, and I felt privileged to be able to show it; I doubt if the thousand or so people who attended my lectures in Edinburgh and Paisley included many customers for lasers, but I'm sure they all went away feeling that exciting research is going on in Scotland under the Ferranti banner.

Yours sincerely, Richard M. Sillitto

1.4 1960 - 1969: University expansion; Associate Dean; Quantum Optics summer school

The Sillitto-Haig experiment was carried out in a poorly insulated hut known as ‘the old rifle range’ just inside the Flodden wall of Drummond Street. Sandwiched between the hut and the main building was the ‘crystal palace’, a prefabricated system building – a periodic structure – erected to house the new Solid State group, many of whom had a background in crystallography. This influx of talent followed the return from Cambridge in 1964 of Bill Cochran, a friend of Dick's from their undergraduate years. Bill came to a new Chair of Physics; Norman Feather was still Head of the department as Professor of Natural Philosophy. The small Mathematical Physics group under Born's successor, Nick Kemmer, was now housed separately on the opposite side of Drummond Street. Student numbers also were increasing rapidly at the time, and the University decided that Physics and Mathematics should share a new building on the Kings Buildings campus a mile to the south. Meteorology, now a separate department, and Computer Science would be housed there too. Dick was deeply involved for a few years as a member of the committee which did the initial planning in collaboration with architect Hardie Glover of Basil Spence & Partners.

In October 1961, Dick was the sole non-professorial member of a small working party appointed to assist the Principal in preparation for a visit from the Robbins Committee, which would be collecting qualitative views on some or all of

Internal Government of the University

Academic Staff<http://www.ed.ac.uk/explore/people/officials/principals.html>

Admission of Students

Type and Content of Courses

He was also a member of the Welfare Committee which always met in the evening because so many of its members were medical people. When geology professor Fred Stewart became Dean of the Science Faculty in 1965 he asked Dick to take on the work of Associate Dean, an office Dick was pleased to retain for a further two years when Hermann Brück succeeded Fred in 1968. This meant that Dick had to spend much of his time in the Faculty office at Kings Buildings. He became a member of many more committees, convening some of them, in the Faculty, the wider University and beyond. According to Aubrey Manning, “Dick was a big influence on the University in one of its golden ages”. With Fred, he oversaw the creation of the departments of Geophysics and Science Studies. He inaugurated conferences for new lecturing staff; membership of the Scottish Universities’ Council on Entrance for the next six years saw him traveling frequently, establishing links with colleagues in other institutions. He was also a member of the Senatus Academicus in the years of student rebellion and Gordon Brown as Rector. Ken Bowler recalls Dick’s “integrity and plain commonsense in dealing with every aspect of university life”. For many years thereafter he represented Edinburgh University on the Court of Stirling University.

Since 1962 Dick had been external examiner for the Physics department at Dundee, and he continued in that role for a couple of decades. The 1960s saw his first invitations to act as external examiner for PhD students, from George Series in Oxford and Leonard Mandel at Imperial College. He valued particularly the work with Mandel, who later went to Rochester to collaborate with Emil Wolf.

In 1966 Dick submitted a proposal to the Scottish Universities Summer Schools in Physics:

The striking advances in the classical theory of optical coherence in the decade before 1960 have now been followed by an equally striking - and almost certainly more important - development in the quantum theory of optical phenomena. Glauber’s ‘coherent state’ formulation of quantum electrodynamics seems to be the appropriate medium for discussing the profound questions posed by the ‘optical beat’ experiment of Forrester, Gudmundsen and Johnson, the optical intensity correlation experiment of Hanbury Brown and Twiss, the development of the laser, and subsequent related phenomena, and gives a new insight into the different characters of the fields encountered in traditional physical optics on the one hand and in laser optics and radio-physics on the other. Sophisticated experimental studies of photon statistics offer a new technique for the study of the interaction of radiation and matter in non-linear systems - crystals and plasmas - and interest in the underlying theories is rapidly growing

among workers in many fields.

A summer school on Quantum Optics and Electronics was held at Les Houches in 1964, and the lectures delivered there have been published (Gordon and Breach, New York, 1965). There was a summer school on related topics in western Canada in 1965. The subject is developing so rapidly that another in 1967 or 1968 would not be premature.

Possible topics and suitable speakers were suggested.

And so, the 10th Scottish Universities Summer School in Physics would be on *Quantum Optics*, co-directed by Dick and Peter Farago (who now held one of the newly introduced Personal Chairs) with Alastair Rae as Secretary. For three weeks in July 1969 the historic Carberry Tower in Inveresk was occupied by a dozen internationally renowned speakers and over 50 enthusiastic postgraduate researchers from 16 countries, with an intensive programme of lectures, seminars, and shared meals. It was not all work: Edinburgh lecturer Bill Taylor, who was on the organising committee as a Steward, arranged a showing of the film *Culloden*, lecturer and clarinet player Ron Mackie brought his quartet to perform classical music, and a group of Gaelic singers came another evening. The other Steward, Dick's PhD student Catherine Woods, organised transport for various outings – a trip to the Bass Rock was long remembered by those who went. Some of the Americans felt that the menu was rather low in protein, so they bought a sheep from a local farmer and arranged a barbecue. On the other hand, Jan Peřina and Richard Horak from Olomouc in Czechoslovakia (as it was then) found even the everyday food “too rich”. Dick had invited Jan to attend and give a seminar when he found that a recent paper of Jan's contained some new results he himself had just derived; their meeting at Carberry was the beginning of a life-long friendship and fruitful long-range interaction, though it was to be 25 years before they met again.

1.5 1969 - 1975: Sillitto-Wykes experiment; move to Kings Buildings; classical optics

About this time Dick explored the possibility of enhancing the students' experience with short films. He and David Vass went to the Calton Studios one day. Without any opportunity for rehearsal or re-takes, David presented an experiment from the second year laboratory and Dick made a separate film introducing its theory. These were used for several years, but their cost effectiveness did not merit further productions.

Catherine Woods had come to Edinburgh with a Masters degree from Galway, with a view to doing a PhD; before her thesis was complete she married Peter Farago's student, and later collaborator, John Wykes. Dick suggested she use a Kerr cell in an experiment to look for a predicted effect about which there was some controversy. In 1956 Hungarians Jánossy and Nagy had suggested an optical experiment in which the two paths of an interferometer would be alter-

nately occulted by a shutter – say a shutter which oscillated so that it always blocked one path or the other, but never both. They questioned whether interference would take place in such a case, and indeed it does at first sight appear that the necessary condition for interference – that there should be no way of knowing along which path the light detected at a given instant has come – is not satisfied. However Mandel showed in 1959, on the basis of classical coherence theory, that an interference pattern should be expected provided that the mean interval between successive openings of either beam is less than the coherence time of the light; the visibility envelope, however, would not be the same as in the absence of the shutter. The Sillitto-Wykes experiment was completely successful.

Dick was pleased to contribute a paper about this experiment, *New Light on Optical Interference*, to the 1971/72 *Festschrift* edition of Proceedings ‘A’ of the Royal Society of Edinburgh in honour of Norman Feather’s 25-year period in the Chair of Natural Philosophy. Another of the 30 or so contributors was a young lecturer, G M Thomas, who had joined the department in 1959 after a spell with the British Antarctic Survey. Gwynne attended the Quantum Optics Summer School, and thereafter spent much time in discussion with Dick. His elegant paper, *The Zeros of the Optical Coherence Functions and their Utility in the Study of Spectra*, “was not concerned with rigorous mathematics, but rather concentrate[d] on explaining to the experimentalist how a knowledge of these zeros can help him extract from his measurements the fullest possible information”. Sadly, Gwynne developed a nerve-wasting disease soon after the department’s move to Kings Buildings, and he died in 1973. At the suggestion of post-doc Mary McCann, his colleagues planted a tree in his memory at the back of their new James Clerk Maxwell building.

1971 had seen the start of the move to KB, though first and second year classes would continue in Drummond Street and the Appleton Tower until 1974. Peter and Dick now had separate offices and a number of laboratories in the new building. Dick received support from the Ministry of Defence for a study of the evaluation and optimisation of optical imaging in partially coherent light. This was suggested by Norman Davidson, the man who had recruited Nigel Haig three years earlier. Funding was provided for a graduate student. Advertisements produced only one applicant with the necessary background in both optics and computing, American Eric Kintner fresh from coursework for an astronomy PhD in Maryland. To appoint him special dispensation had to be obtained, on the grounds that there was no-one in the UK who could do the work. Professor Feather referred to Eric as “Dick’s mail-order student”. His 4 years’ work for a PhD was very productive. He developed a new performance indicator to gauge the tendency of a system to produce edge-ringing, and a new analytic method for computing the Optical Transfer Function. The facilities of the Edinburgh Regional Computing Centre in the same building were vital to this success.

Some of the equipment of the Sillitto-Haig experiment was transferred to one of the new labs; Winifred Sillitto re-assembled it in a light-tight box made in the new departmental workshop, and re-designed the coincidence counting circuitry, before handing it over to postgraduate student Joan McMillan. Joan was able to produce the long-expected results for two different wavelengths of

the mercury discharge.

Winifred, prompted by a problem raised by a student in the laboratory where she was a demonstrator, started on a series of computer-based simulations and experimental investigations using laser light, of classical Fraunhofer diffraction at regular polygonal apertures, creating projects for final year students. This tied up with Dick's interest in the symmetry properties of the Zernike polynomials in relation to lens aberrations, on which he was working with Eric.

In September 1974 Dick had a brief visit from Monash University's Gordon Troup who, with his colleague R G Turner, had just prepared a review of optical coherence for *Reports on Progress in Physics*:

Abstract. An account is given of optical coherence theory as it existed in the 1950's when, essentially, only thermal sources and slow detectors were available and it sufficed to characterize the coherence and polarization properties of an electromagnetic field by second-order correlation functions. The necessity for a more sophisticated specification of the coherence properties of fields, involving the use of higher-order correlation functions, first hinted at by the Hanbury-Brown-Twiss experiments and emphasized by the advent of the laser, is then introduced. Both classical and quantum mechanical treatments are discussed, each leading, in almost all cases of practical interest, to similar results. It is seen that the development of fast detectors enabled the higher-order correlation functions to be measured using photon counting techniques and an account of experimental work verifying the complete theory using such techniques is given. The review concludes with a discussion of some developments in associated areas whose origin lies in the resurgence of interest in coherence theory during the last decade.

Shortly afterwards Robin Turner came to Edinburgh on a year's sabbatical, and worked on the shifts of coherent light beams on reflection at plane interfaces between isotropic media. A younger man came from Monash, too. Ian Every arrived on a cold wet night in Jan 1975 to spend two and a half post-doctoral years, some of the time thinking about the very controversial Schwarz-Hora effect. He then joined the Open University where he continues to develop the interactive use of computers to help students learn.

1.6 1975 - 1980: International Conference on Physics Education; unfinished book; option in Modern Optics

1975 was the year of Professor Feather's retirement. To honour his contribution to teaching, IUPAP decided to hold its *International Conference on Physics Education*, funded by UNESCO, in Edinburgh for 3 weeks in July of that year. Dick was asked to organise the local input. He agreed only out of respect and affection for Feather, for he had little interest in the educationalists' jargon-ridden approach to the subject and felt it was a colossal waste of the department's time. Fortunately senior lecturer Peter Kennedy was more excited and enjoyed

the committee work and meeting with Tony French and Ed Taylor from the U.S. whose textbook on *Waves and Vibrations* was being used for the second year class. With Alastair Rae as a very efficient Secretary and help from the department's Francis Barnes, Ken Bowler, Richard Nelmes and Murray Campbell, and Archie Campbell from Napier, among others, the event was a great success.

It was a glorious summer. Most of the 330 participants, and many 'accompanying members', were housed and fed in Pollock Halls and various entertainments were laid on for them there. Winifred arranged outings, and one-to-one meetings between the 'accompanying members' and wives of members of the department. At a final reception in the Upper Library Dick was delighted to share the hand-shaking with the Principal of the University, Sir Hugh Robson, an old friend from his youth. Norrie Robson's father had been excise officer for Langholm, the district neighbouring Dick's father's territory of Lockerbie and Dumfries, and Dick as a student shared Norrie's digs in East Preston Street (their landlady always made sure they ate kippers before going out on a date).

Dick did in fact meet a few congenial participants at ICPE, in particular astrophysicist Denis Coates from Australia who was at the time working in Milton Keynes on a new Open University course, S291: *Images and Information*. Later, Dick was external assessor and consultant for many years for that course, and gave considerable input to its re-write for 1992.

Dick had long been aware of the need for a book at final year physics undergraduate level which would show how the new trends in optics were rooted equally in traditional optics, statistics, and quantum theory. By 1977 he had completed a text in draft, save for half of the final chapter and the whole of one appendix, and a few chapters had been typed. A publisher was interested, but Dick felt no confidence that he could complete the work in the suggested time and would not sign a contract. [Ironically, about the same time Joseph W Goodman, of Stanford, was writing a book at a similar level. Although Goodman had had a whole year's sabbatical leave with no other commitments, it was not until the year 2000 that his *Statistical Optics* was published.]

For several years from 1977 Dick served on the committee of the Optical Group of the Institute of Physics. In 1981 he was invited to join the Editorial Board of *Optica Acta* by Lionel Baker of NPL, and remained on the board when it became *Journal of Modern Optics* under the editorship of Peter Knight, retiring in 1997.

In the late 1970s Dick shared supervision of PhD student Isa Daudpota with fluid dynamicist Clive Greated, in a study of particle image velocimetry. He also introduced an honours option on Modern Optics. "Gold star for Dick Sillitto" was the verdict of one of those who chose it in 1980, outstanding among them Karen Ness and Will Hossack. Karen went on to Imperial College and in 1996 became pioneering Chief Executive of the Institute of Photonics at Strathclyde. Astronomer Alison Campbell remembered Dick's "electrifying, totally unforgettable" demonstration of two-slit interference at very low light levels as *The most beautiful experiment*. A graduate from 1982, remembering the course which introduced him to an extra layer of beauty behind the rainbow, recalls:

“It is the last lecture of optics in second year. We have been told to expect something special. We expect a gimmick – holography perhaps. Instead, Dick resolves the sodium D lines on the ceiling of the lecture theatre. We go away wowed.”

1.7 1980 - 1990: Born centenary; Applied Optics group; Reader Emeritus

1982 was the centenary of the birth of Max Born, and the IOP Optical Group decided that its September conference that year should be held in Edinburgh in Born’s honour. Some of the new graduates who had followed the Modern Optics option were more than willing to be pressed into service as ushers. Emil Wolf was the guest speaker, visiting Edinburgh for the first time in 28 years to give an account of his time with Born.

The character of the university had changed. “Academia is no longer the life for a gentleman” Bill Cochran was to say when he retired in 1988, prompting solid state theorist Alastair Bruce to comment wryly “and no longer the place for a scholar”.

Physics now had a Head of Department democratically elected by the academic staff, and there was great pressure from the University administration to establish close links with industry and to secure large scale grants from the Research Councils. In 1982 Roger Cowley, as HoD, encouraged all staff to concentrate their research efforts within larger groups so that the Department could bid more effectively for external funding. In response seven academic staff (Dick, now a Reader, George Bradford, Dick Dougal, Norman Fancey, Stuart McKirdy, Alastair Rae and David Vass) came together bringing expertise in optics, electronics, microcomputers, computational physics, photon detection and management to explore possibilities for image processing and pattern recognition in real time using coherent optical processors. The following session David Wallace (who had been an undergraduate in the late 1960s and was now Tait Professor) was elected as the new HoD. He was very supportive when Dick suggested setting up an Applied Optics Group involving about 20% of the academic staff in the Department.

Under Dick’s leadership, academics, research staff and postgraduate students cooperated enthusiastically to develop an idea from David Vass - liquid crystal over a silicon chip for use as a spatial light modulator in coherent optical data processing. The first chip with 16x16 pixels was made between 1984 and 1985, and this involved close collaboration with the Department of Electrical Engineering, a collaboration which has lasted for over two decades. Since the demands of the design exceeded the then computing capacity at the University, access was gained to national computing facilities at the Rutherford Appleton Laboratory at Harwell. (One year the Group’s requirements exceeded the whole budget allocated for micro-fabrication at RAL but SERC provided additional funds.) Strong links were forged with industrialists at STC Harlow, GEC Marconi Chelmsford and later CRL Hayes as well as with groups doing similar work at UMIST, Manchester, and Boulder, Colorado.

During this exciting period in the 80s more than a dozen talented research students and research workers joined the Group. Winifred helped several of them develop a better understanding of the diffraction of light at the regular arrays of pixels in the SLMs. Some continued their careers in the rapidly developing field of optoelectronics - Ian Underwood became a lecturer and later professor in Electrical Engineering, spinning out a very successful company, Micro-Emissive Displays (MED); Douglas McKnight joined Heriot Watt and later Boulder Displays; Mike Snook after many years service joined MicroPix, a company set up by the Group's industrial collaborators to exploit the liquid crystal-over-silicon technology; Alastair MacGregor joined a consultancy company in Cambridge; and Steven Heddle worked on image processing in the Royal Observatory on Blackford Hill for a few years before returning to his native Orkney. Will Hosack, a former undergraduate at Edinburgh, came back to join the Group as a lecturer in 1990. A DTI/SERC grant enabled successful production of a 176x176 pixel SLM in 1990, involving GEC, STL, UMIST and Edinburgh. This was Dick's last major grant before his retirement, and it was hailed by the external assessors as a flagship project of the UK JOERS programme to promote new optoelectronics technologies.

A very different industrial connection was made in 1986 when Strand Lighting asked for help with their flood/spot theatre luminaires. Dick undertook a redesign in co-operation with Strand staff in Kirkcaldy, and was able to make considerable improvements. On another occasion, he was asked to meet representatives from a firm in the north of Scotland which was having difficulties with its devices for undersea visual monitoring. Dick identified the problem there and then, and outlined how it could be overcome. University-industry liaison was not pleased when the firm decided that, with what Dick had told them, they could now solve the problem themselves.

In 1988 Reading's Optics department invited Dick to be external assessor for their MSc course. This gave particular pleasure to one of his long-standing admirers - Brian Blandford, who had taken the quantum mechanics course in 1963-4 as a mathematics student in the Arts faculty. Brian went on to Reading to do a PhD with Harold Hopkins, and became one of the country's leading lens designers.

Between 1987 and 1990 Dick was Meetings Secretary of the Royal Society of Edinburgh, an enjoyable duty which involved writing detailed minutes of lectures on a wide variety of topics.

In June 1990 Emil made a third visit, and was awarded an honorary degree.

In September 1990 Dick was declared Reader Emeritus, at a reception in the Upper Library to mark his retirement 50 years after he had first come to Edinburgh as a student. At the end of October he was in Glasgow to give a talk to the Glasgow Royal Philosophical Society. The Society's President was Leslie Barr, professor of physics at Paisley College where Dick had been external examiner from 1977 to 1980. Leslie had specially requested that the talk should be about the Maskelyne experiment. Like Alastair Rae, Leslie had been one of the second cohort whom Dick had taught to play croquet at *The Burn*. Following

the meeting and a luxurious night in one of Glasgow's best hotels, Dick and Winifred set off through the Trossachs in the first snow of winter on the first day of November, with a sense of freedom at last.

1.8 1991 - 2005: Health problems; lectures; reviews and refereeing

Freedom for Dick to get to grips with five problems in optics which had intrigued him for years. But first, there was a book to work on. Longman's had asked him to edit and update Longhurst's *Geometrical and Physical Optics*. He started on this with enthusiasm after moving to Dunbar in the spring of 1991, taking the train to Edinburgh from time to time to spend a day in the library. After one such trip he was exceptionally tired; his GP suspected a problem with his heart, but the ECG seemed normal. However, he got more and more tired throughout the next few months and the following summer had a severe attack of angina, the day before he and Winifred were to set off on a visit to the Peñinas. He was forbidden to fly. With visits to clinics and with Longman's pushing him for a completion date, he had to abandon the book. Medication did make life easier for him and he continued with a variety of activities, though he had to spend a week in the Royal Infirmary of Edinburgh in October 1993.

In the next few years he made several visits to Imperial College, for JMO board meetings and for IOP Optical Group conferences; to Milton Keynes as consultant for the rolling re-write of the *Images and Information* course; and to Reading to present his final report on the MSc course and to give a lecture. By request, this lecture was a repeat of one Dick had given in April 1993 to a meeting of the History of Science group of the IOP, subtitled *The durability of Maxwell's electromagnetism*. In a letter to Emil in August, he wrote

The April meeting was an odd one. It was the biennial conference of the History of Physics Group of the IoP, which got mixed up with the annual Edinburgh Science Festival, and with the James Clerk Maxwell Foundation which is an Anglo-American body committed to inspiring the young to follow in James Clerk Maxwell's footsteps; they have just completed the purchase of JCM's birthplace (14 India Street) from its previous resident owner.

So the meeting was advertised through a variety of channels, and the speakers included an actuary who had been sorting out Maxwell's ancestry; an art historian who had been collecting and sorting the paintings of Maxwell's cousin Jemima Wedderburn, which included a lot of family sketches and drawings; a professional scientific historian who has made a special study of the development of the electromagnetic theory; and Sir Brian Flowers and myself who were asked to talk about science!

What kind of audience we could expect no-one could predict, but in the event they included some high-powered physicists, some low-powered physicists, a few lawyers, and others. There were twice as many people as had been planned for, and Brian Flowers and I talked

at very different levels, so I'm not at all sure how my talk went over. I think it was quite a feat, though, to talk about quantum optics without a single equation! Whether it was worth it – except for me – I'm not sure.

In 1992 Emil had invited Dick to join the Editorial Board of *Progress in Optics*, and in 1993 he was elected to Fellowship of the Optical Society of America. The Science Faculty in Edinburgh was 100 years old on 18 February 1994; Dick collected information from his former colleagues and compiled an account of the history of the Physics department for inclusion in the book marking the occasion. Another happy occasion was the *Electron Physics* symposium in honour of Peter Farago. Dick spoke about Peter's early years in Edinburgh, after the symposium dinner in the RSE rooms on 1st April. In August, Jan and Vlasta Peřina spent a ten day holiday in Dunbar. This overlapped with their son's attendance at the 44th Scottish Universities Summer School in Physics, *Quantum Dynamics of Simple Systems* held at Stirling. Roy Glauber, who had taken part in the 10th Summer School at Carberry 25 years before, was among the lecturers at the School. The School's directors invited Dick to a social gathering to meet him again, and it was a happy coincidence that Jan was able to go too.

Refereeing and book reviews – for the *Journal of Modern Optics*, *Contemporary Physics*, and various *Institute of Physics* and *Optical Society of America* journals – kept Dick in touch with physics for almost the rest of his life, with some breaks. As a referee he always took great care to suggest logical and grammatical improvements, and further references, for papers which were not suitable as they stood, and enjoyed the many occasions when the authors later thanked 'an unknown referee'.

Severe anaemia saw him in hospital for a blood transfusion in November 1995. Despite occasional hypoglycaemic episodes he was in fine fettle for his golden wedding celebrations in September 1997. But a year or so later he was very anaemic again, collapsing while queueing for baked potatoes in a café in Dalkeith. While in hospital he found reading impossible until his grandson lent him the first Harry Potter book (he refused to read any of the later books in the series). Coeliac disease was diagnosed in May 1999 and after only a week without wheat he was transformed into a happy active man, gradually recovering his ability to understand scientific literature.

A gluten-free diet does not fit well with diabetes and the need for regular carbohydrate, and hypoglycaemic incidents happened more often. A particularly severe one occurred in the early hours of Christmas Eve, 2001. A locum in his first appointment was sure Dick had had a stroke – a possible misdiagnosis which Dick's own GP had been warned about in medical school – and there was nothing to be done for him. When the doctor left at dawn Winifred did another test and found that Dick's blood sugar had increased. The necessary injection of glucose was at last given after Dick had been unconscious for 5 or 6 hours. His memory was badly affected but it did improve slowly, helped by the reminiscences sent by former colleagues for his 80th birthday on 3rd March 2003.

A change of insulin type in the spring of 2004 gave fresh hope and some further

improvement in memory. He thoroughly enjoyed the event in the James Clerk Maxwell Building in October, when David Vass, Norman Fancey and Francis Barnes retired – the end of an era in the Physics department. However when Emil came to Dunbar in December it was clear that Dick was far from well. Peter Farago died on the last day of the year, and Dick worked on his obituary with Murray Campbell and John Wykes helping by email, as did Alastair Rae, himself terminally ill. Emil had brought a copy of the *Born-Einstein Letters*, and a month later sent *The End of the Certain World*, the biography of Born written by American Nancy Greenspan who had visited Dick during her research for the book. These were the last books Dick was able to read. He commented that each illuminated parts of the other. But he was sad that he could no longer remember what were the five problems he had intended to work on himself. In the end it was bowel cancer that killed him, unsuspected until two months before his death on 19 April 2005.

Dick was a gentle, sensitive man, feeling deeply for other people's troubles. He was courteous to all and willing to listen, even to those he disliked or disagreed with. Ecologist Fred Last's description of him is typical of many tributes:

Dick was always Dick – level-headed with his own brand of humour and utterly dependable – he was a delight.

But I like best the way Margo Rowlands remembers him:

... and somehow fun to be with.

2 Dick Sillitto. In Memoriam.

29 April 2005.

It is an honour for me as well as a sad task to be asked to say a few – I fear inadequate – words about Dick, a friend for almost half a century.

We came to Edinburgh in the Autumn of 1957, the year of the first Sputnik. Dick and Winifred were among the very first people we newcomers got to know. We were neighbours in more than one sense – academically in the university, because my husband Hermann had been appointed Professor of Astronomy – and Astronomy is a near relative of Physics; and also at home, as we lived at the Royal Observatory almost within stone's throw of the Sillittos' famous upside-down house on Blackford Hill where they moved a few years later.

One of our first social functions at the University was the Annual Physics Dinner, organised, I think, by the senior students, and attended by staff and spouses. We all sat at one long table, with Professor Feather in the place of honour. I wonder if they still have these dinners – they would need a lot more than one table to accommodate the same group today. And so, we were kindly received into the academic community where Dick, though still a very young man, was an old hand, a lecturer in Physics who had links with the Department of Astronomy. And so, also, began almost fifty years of friendship, in and out of science.

Winifred and I were young home-based mothers in the early days, and we soon got to know each other. I well remember climbing up the flight of steps to their spectacular eerie for a cup of coffee, or to collect Winifred in the evening to go to our Gaelic classes in the extra mural department of the university. It was some time before I discovered that Winifred was taught Physics in Belfast by the same professor who examined me in Dublin.

Meantime the astronomers on top of the Hill were looking outwards into the new world of space and computers. Dick was one of those who was particularly sympathetic with this renaissance and took an active interest in it. He faithfully attended the observatory colloquia which were set up to bring in outside experts and inspirers. His participation, I know, was greatly appreciated, and continued throughout our time, and indeed to the end of his own university years. In a lighter mood, I remember also some happy social events at the Observatory in which he and Winifred joined as part of our astronomical family.

Hillary has told something of Dick's long and distinguished career in Physics. I would like to add a word about his connection with our Department. He was involved on the teaching side through an Astronomy course in the Physics degree, started as early as 1950 when Michael Smyth, who is one of Dick's oldest friends, became the university's first lecturer in astronomy.

We of the older generation talk about the Physics Department. It is now known as the Physics and Astronomy Department, an amalgamation where the whole is greater than the sum of the parts, and one of Britain's most prestigious centres of research. That union took place after Dick's time at the university. But it was no sudden take-over. The two Departments were integrated academically for more than twenty years through a combined degree in physics and astronomy, called Astrophysics. Again, Dick was closely involved on the Physics side of the syllabus – which included his own almost legendary course of lectures on Quantum Mechanics. A whole generation of Astrophysics students took that famous course. One of them said to me recently that having listened to Dick

Sillitto on Quantum Mechanics, he has been at it ever since: his lectures were rigorous and erudite, but wonderfully illuminating. As a teacher of undergraduates Dick had the reputation of being patient and approachable. I heard the same from many of the students who came our way. They were in awe of his learning, but not of him. He was a perfectionist but no pedant. Every student whom he ever taught would give the same verdict.

After Dick's eightieth birthday two years ago, Hillary had the lovely idea of compiling the greetings and reminiscences which came from colleagues and former students all over the world. What is most striking when you read this Birthday Book is how Dick's gift of communication emerges as the recurring theme of all those who passed through his hands at university: they use words like "lucid", "bright" and "beautifully clear" in reference to his teaching. What Dick imparted went beyond physics. One of his former students, Howard Firth, Director of the Orkney Science festival, wrote in his tribute:

"Of all the skills that we need to draw upon in life and in science, clarity of thought is up there at the very top, and Dick Sillitto's teaching simply glows with it."

Another alluded to "the beauty of Optics". Optics was the field in which Dick was internationally renowned; but to him it was much more than a utilitarian science; it was something truly beautiful, like art or music. It is not surprising that Dick loved these, too. It was all of a piece.

To me, Dick was the embodiment of a scholar. He was deeply interested in learning, and in passing on the fruits of his study and reflection to the next generation - one of the ancient ideals of a university. His academic prestige brought him into the spheres of some great scientists, quite a few of whom he himself had launched; and in the course of a long career he had dealings with many important people in the university, at the Royal Society of Edinburgh, and in the Institute of Physics. But it made no difference. Dick was always the same Dick - without a trace of vanity or self-importance, kind, polite, helpful. The passing years found him still the same. I think that is what made him such a very special and lasting friend to so many of us.

And he had many friends, including his numerous university colleagues. But I think he was at his best among just a few friends at a time. He was a thinker, not a great talker, certainly not a chatterer, and what he said was worth listening to. His and Winifred's home was an oasis of serenity. They loved books and beautiful things, paintings and ceramics. I have a particularly happy memory of dinner in the Blackford Hill house on a summer evening, looking out over the city of Edinburgh, and talking about some of the great masters of Dick's earlier days - Whittaker, Born, Schrödinger - because Dick was immensely knowledgeable not only on the latest developments in physics, but on its history and its roots. When his teaching life came to a close, our venerable university conferred on him the rare title of Emeritus. It was especially fitting, because Dick could never really retire, or give up the pursuit of his beloved Physics. He was and remained always the scholar. I had the joy of visiting him just last summer in their beautiful home here in Dunbar, sadly for the last time.

It was a privilege to have known him.

Maíre Brück

