John T. Lewis (1932–2004)

JOSEPH V. PULÉ

The death of John Lewis on 21st of January 2004 was a great loss to the Irish mathematics community and to the broader Mathematical Physics community.

I start this tribute to John's life and work with a short biography. Afterwards I describe briefly some of his main contributions to the areas in which he worked. I am indebted to many of his collaborators and friends for helping me in this task.

John Trevor Lewis was born in Swansea, Wales, on 15 April 1932 to Tegwyn and Trevor, a shipbroker. In primary school one of his teachers was Thomas George Thomas (Lord Tonypandy), who became an M.P. and later speaker of the House of Commons. John was always amused later on in Dublin when turning on the BBC in the morning to hear his old teacher call out in a Welsh accent the ritual cry "Order! Order!" He was educated at Cardiff High School. He spoke very highly of one of his mathematics teachers, Mr Arthur Davies, who was the father of Brian Davies at King's College London. After the Second World War the family moved to Belfast, John attended the Royal Belfast Academical Institution and later went to Queen's University Belfast. In 1955, he was awarded his doctorate in applied mathematics by Queen's. During his stay in Queen's he came in contact with the poet Philip Larkin, who was then sub-librarian and according to John was always helpful. John later came to admire his poetry. His official PhD supervisor was David R. Bates but he worked mainly with Alexander Dalgarno. His doctoral thesis introduced the widely known Dalgarno–Lewis method in quantum mechanical perturbation theory, which appears in most standard texts. Two of his papers with Dalgarno are still widely cited today. He became a Research Lecturer at Christ Church, Oxford in 1956. The original reason for going to Oxford was to work with Charles A. Coulson with whom he published one paper. But he found other areas of mathematics much more stimulating and started to work on group representation theory. He became a Tutorial Fellow in Mathematics in Brasenose College in 1959 where he was Dean for some time. As a dean he started to develop his considerable political skill which was very useful later on in 1988 in reversing the government's decision to close DIAS. He was appointed to a University Lectureship at the Mathematical Institute Oxford in 1965.

While at Queen's John met Maureen MacEntee, an organic chemist. They were married in September 1959 and had four children, Caitríona, Michael, Roisín and Ciarán, all born in Oxford. John kept in touch with Irish affairs and took part in the Human Rights marches in Oxford in support of the corresponding ones in Northern Ireland. He was also external examiner to the Mathematical Physics Department in University College Dublin and collaborated with David Judge in that department on the commutation relations in Quantum Mechanics.

This period saw the birth of rigorous Mathematical Physics, with work by George W. Mackey, Arthur S. Wightman, Res Jost, James Glimm, Arthur Jaffe, Klaus Hepp, Huzihiro Araki and others. Up to that point, except in exceptional cases like John von Neumann's book on Quantum Mechanics, it was not felt necessary or worthwhile to give a mathematically rigorous approach to Theoretical Physics, especially Quantum Mechanics, Quantum Field Theory and Statistical Mechanics. This method of dealing with physical ideas appealed to John; he argued that a deep understanding of the underlying mathematical structure provided new physical insight. From then on John never deviated from this method of working; he felt that this was his way of *understanding* and when asked to explain why, he would answer, "You have to ask my psychoanalyst". Though this reply was not supposed to be serious it described accurately his compulsion for finding mathematically concise and economic explanations for complex physical ideas.

While at Oxford he supervised fifteen successful doctoral candidates, many of whom have become renowned academics in their own right. His first student was Robin Hudson who later became one of the leaders in the theory of Quantum Stochastic Processes. This field had its origin in John's pioneering work with Brian Davies on quantum measurement, with Lyn Thomas on the quantum Langevin equation and later work with David E. Evans. In 1969, John spent a year at the Institute for Advanced Study in Princeton, New Jersey, and Rockefellar University, New York. His interaction with Mark

Kac, there and later, strongly influenced his research interests. In New York Mark Kac introduced John to the area of quantum probability. Later in 1970 he visited Oxford and brought with him a manuscript on calculating the thermodynamic functions of the Bose gas. I was then John's student and he suggested that we should work on Bose–Einstein condensation, a topic that continued to interest John for most of his career. Around this time he met André Verbeure and though they collaborated on only one paper much later, they became very close in their support of the international Mathematical Physics community.

In 1972, on the retirement of John L. Synge, John came to Dublin to take up a Senior Professorship in the School of Theoretical Physics of DIAS. Synge was another strong influence on John's mathematical thinking. He admired Synge's originality and they became close friends. When Synge became very old and housebound John visited him weekly for mathematical discussions and anything that he needed. John served as Director of the School from 1975 until his retirement in 2001. John always saw the School of Theoretical Physics as a meeting point and focus for Mathematicians and Theoretical Physicists in Ireland. One of his first acts as Director in DIAS was to introduce an open access policy to its facilities, enabling scientists from all over Ireland to further their research. In 1988, the Government had more or less decided to close DIAS. There are many people who can claim a share in reversing this decision but John's part was certainly very important and significant.

During the 1980's John was a frequent visitor to Warwick where his former student John Rawnsley was appointed at the same time as David Evans. John's counsel was frequently sought during these visits and indeed he served as an advisor to the Mathematics Research Centre. Also at this time, through Marinus Winnink and Nico Hugenholtz, John developed very close relations with Groningen which provided some outstanding postdocs and PhD students for DIAS.

John also had strong links with the University of Wales especially after Aubrey Truman, David Evans and Tony Dorlas were appointed. He was influential in bringing the Congress of the International Association of Mathematical Physics to Swansea in 1988, which significantly helped Swansea's reputation as a serious centre for Mathematical Physics, serving as Vice-Chairman of the Scientific Organising committee. He was delighted to be appointed Honorary

Professor at Swansea and Cardiff and was a frequent visitor to Wales in the last two decades, combining scientific visits with visiting family members. In July 1997 he returned to Swansea with Maureen for a conference in honour of his 65th birthday when many of his collaborators and students congregated. His last visit to Wales was in November 2002 when he was the principal speaker with Vaughan Jones at the LMS Regional Meeting in Gregynog.

John had great sympathy for scientists, in particular Mathematical Physicists, from Eastern Europe. He felt that they should be visited as much as possible and helped to meet other scientists from the west. He exploited Ireland's neutrality and in spite of huge visa problems there are a considerable number of scientists from the former Eastern block whose first trip to the west was to DIAS. He established strong scientific and personal links with the Institute for Problems of Information Transmission in Moscow through Yuri Sukov and later with the Joint Institute for Nuclear Research in Dubna mainly though Valentin Zagrebnov and Vycheslav Priezzhev. Some of these left their country and some stayed after the collapse of the Eastern Block but all of them are very appreciative of John's effort to help them. Another serious concern to him was the position of science in world affairs. In 1971, he helped to found the Irish branch of the Pugwash Conferences on Science and World Affairs. John was elected president of the Irish Federation of University Teachers (IFUT) just before the Government announced its 1987 decision to close Carysfort Training College and was tirelessly engaged with the government about the problem until a solution was found.

John was elected to the Royal Irish Academy in 1977. He was on the Council from 1985 to 1989 and from 1997 to 1999 and Senior Vice President from 1999 to 2001. John was a gifted teacher with an enviable ability to get to the core of a subject stripping it of all inessential details, presenting it clearly and concisely. In Dublin, although his position was free of teaching duties, for 24 years, he offered statistical mechanics and probability theory courses to undergraduates. He was never satisfied with his presentation and constantly searched for improving his method of giving the students a deeper insight into the subject. He approached his publications in the same way. The writing process for him was painfully slow and meticulous. I have known him to rewrite the draft of a paper in his very clear handwriting seven times. This was before the age of mathematical word processing.

John had very strong likes and dislikes. He could take an immediate dislike to people that he thought were pompous and self-important. However he would put up with any inconvenience and bother if he thought that a person was a good mathematician or scientist. John hated bandwagons. If he thought that a problem was worth investigating he would go ahead independently of whether it was fashionable or not. He was convinced that good work will eventually be appreciated. The fact that he was right is borne out by the number of recent citations to his work with Brian Davies on quantum measurement. He was also very dismissive of people who published for the sake of publishing and was not impressed by the number of publications; he was more interested in the content of the papers.

John was genuinely worried about extremely gifted young mathematicians not getting employment and had been thinking for some time about setting up a group in applied probability. He was convinced that this area while being intellectually and technically challenging would make PhD students and postdocs working in this area more employable. On his visits to Moscow, John was impressed by how the Institute for Problems of Information Transmission operated; researchers there spent half their time on practical problems directly applicable in telecommunications and the other half on basic research. He thought that he could make this work in Dublin. The opportunity came in 1996 when backed by an extremely original insight on how to measure Internet traffic using Large Deviation Theory, he persuaded the Computer Laboratory in Cambridge and the Swedish telecom operator Telia to join him in a three-year research contract funded by the European Commission. The technology developed during the project was to prove sufficiently successful to warrant John co-founding a company, Corvil, to exploit the intellectual property. Corvil currently employs over seventy-five people, seven of whom are PhD level mathematicians. After Corvil received seed capital and a high-powered management team were recruited, John returned to scientific research. He bid successfully for a prestigious Principal Investigator award from Science Foundation Ireland. In 2001 he and his team established the Communication Networks Research Institute (CNRI) in the Dublin Institute of Technology.

John's impressive scientific work is certainly a monument to his memory. His friends and collaborators will remember him for his ability, enthusiasm, insight, encouragement and eagerness to help. Many mathematicians would have never considered research or the academic life without John's influence and have him to thank for making their lives so fulfilling. While considering John's contribution to science, we should not forget the contributions that he made to many of our lives.

Below I describe John's work very briefly. His early work with Dalgarno in quantum mechanical perturbation theory appears in most standard texts and needs no further comment.

Quantum measurement theory. This important work with Brian Davies was inspired by the work of George W. Mackey who gave a series of lectures in Oxford in 1966/67. In order to provide a mathematical framework for the process of making repeated measurements they proposed a mathematical definition of an instrument which generalized the concepts of observables and operations. This definition made it possible to develop such notions as joint and conditional probabilities without any of the commutation conditions needed in the approach via observables. One of the crucial notions was that of repeatability, which they showed is implicitly assumed in most of the axiomatic treatments of quantum mechanics, but whose abandonment leads to a much more flexible approach to measurement theory.

How to make a heat bath. This is the title of one of John's papers, which as usual encapsulates the problem in a few words. The work was motivated by the Ornstein–Uhlenbeck model and the model of a heat bath proposed by George W. Ford, Mark Kac and Peter Mazur. The basic problem considered is the modeling of dynamical systems wherein friction or dissipation emerges in the statistical description of a *small* system: given the dissipative irreversible dynamics of the small system how does one construct a reservoir so that after the restriction or projection of the reversible dynamics of the larger system one recovers the dynamics of the small system. John started this programme with his then student Lyn Thomas in the Hilbert space setting in his thesis (1971). In 1975 David Evans came from Oxford to work as a scholar with John at DIAS. He had sat in on John's MSc class as an undergraduate during John's last year in Oxford in 1971–72. Inspired by these lectures, he pursued graduate work under the supervision of Brian Davies. His thesis contained a study of dilations of dynamical semigroups on operator algebras. This was the beginning of realising systematically open systems in closed ones via dilations as, e.g., had been suggested in John's work. David Evans and John wrote a series of papers on dilations of dynamical semigroups, culminating in a monograph, *Dilations of Irreversible Evolutions in Algebraic Quantum Theory*. This collaboration during 1975–77, particularly the monograph, has been widely influential in the subsequent developments of quantum probability.

Quantum Stochastic Processes. In 1969, John spent a year at the Institute for Advanced Study in Princeton, New Jersey. While there he visited Rockefeller University, New York, where Mark Kac suggested that they consider the problem of quantum stochastic processes. Back in Oxford, John started working on this problem with Lyn Thomas. In New York Mark Kac introduced John to George (Bill) Ford from the University of Michigan, who was visiting Rockefeller at the time. This was the start of a collaboration that lasted the rest of John's life. Their seminal paper on quantum stochastic processes was published some years later, but in the meantime their collaboration resulted in important work on quantum master equations and rotational Brownian motion. In 1984, Robert O'Connell from Louisiana State University joined the collaboration on a broad program of research dealing with fluctuation and dissipative phenomena in quantum mechanics, making extensive use of a quantum Langevin equation among other tools. This collaboration, which was facilitated by annual summer visits by Ford and O'Connell to the DIAS, resulted in thirteen publications.

The Ising Model. When John moved from Oxford to Dublin in 1972, he took with him Peter N.M. Sisson, a graduate student who completed his PhD at Trinity College Dublin in 1974. In 1972 Serguei Pirogov had shown that the thermodynamic limit of the Gibbs state in the two dimensional Ising model induced a pure state on the Fermion algebra containing the transfer matrices, at all temperatures so the phase transition was not apparent in this algebraic context. This problem was the basis of joint work between John and Peter Sisson. They showed that the phase transition was related to a jump in the index of a certain Fredholm operator, which John and Marinus Winnink later related to non-Fock quasi-free states on the half lattice which were only primary at high temperatures. The full lattice in the setting of Pirogov remained tantalisingly open. John returned to this problem later and a second collaboration with David Evans took place during 1982–86, when the latter was at Warwick. This was a return to the operator algebra framework for understanding the Ising model with two papers by David Evans and sandwiching in time one by Araki and Evans. This completely resolved the puzzle of Pirogov on the full lattice. On the Pauli algebra (only whose even part is canonically identified with the even part of the Fermi algebra), the state induced by the Gibbs state with periodic or free boundary conditions is pure for high temperatures and impure for low temperatures. The automorphism method initiated by them for relating the Ising model at different temperatures and hence giving a better understanding of Pirogov's puzzle, has become a standard tool.

Do Bosons condense? Although Bose–Einstein condensation was discovered in 1925, there is still no rigorous proof that interacting bosons do condense. One of John's important contributions in this area is the realization that the condensation mechanisms can vary radically in different models. John's interest in Bose–Einstein condensation started with a visit by Mark Kac in Oxford, who introduced him to the problem. Together with me, he started by considering the free Bose gas, including the rotating gas, giving a complete rigorous analysis of the phase transition in the framework of C^*-algebras. Kac had pointed out also the inequivalence of ensembles for the Bose gas. We formalized Kac's ideas by introducing what has now become known as the Kac density. Later on in Dublin we went on to consider the mean-field model in collaboration with Michiel van den Berg and Phillip de Smedt. With van den Berg and others John found that an external field as well as an unusual geometry can drastically alter the nature of the phase transition exhibiting condensation in the lower states rather than just the ground state. This is now of relevance for recent experiments where fragmentation of the condensate has been discovered. John also proposed that condensation into the lower lying states, Girardeau's generalized condensation, is what is thermodynamically stable and not condensation into the individual states.

About 1985 at a conference John met Joseph L. Doob, who personally explained him the elements of Large Deviation Theory. This proved to be of great benefit for future research. From one of his famous back-of-an-envelope calculations, John quickly realized that this theory could be applied to obtain a much simpler derivation of the formula for the pressure of a mean-field Bose gas. In collaboration with me and Michiel van den Berg, and later also with Tony Dorlas, this was subsequently extended to the Huang–Yang–Luttinger model of a hard sphere gas and more complicated models. It culminated in a complete description of the most general Bose gas model with interaction diagonal in the occupation numbers. For several of these models the Bose–Einstein condensation phenomenon could be analysed.

Applied Probability. In the 1990s, large deviation theory was used to rigorously deduce from models queuing behaviour that is observed in real network routers. While John co-authored with Wayne Sullivan and Ken Duffy a paper that included one of the most technical and general deductions, his greatest contribution was conceptual. Knowing the large-deviations rate-function of the input to a queue, one could determine the likelihood of extreme queuing congestion. The practical implementation of this knowledge had been to model the input as a Markov chain with many states, fit transition probabilities empirically and then determine the chain's rate-function using spectral analysis, a cumbersome calculation that could not be performed in real-time. Drawing an analogy with chemical engineering, where entropy plays the role of the rate-function, John knew that engineers did not determine a gas's entropy by fitting model parameters, they measured it directly. With his applied probability group he developed this method, which is best described in his 1995 IEEE Journal of Selected Areas in Communications paper co-authored by Nick Duffield, Neil O'Connell, Raymond Russell and Fergal Toomey. The approach was to prove sufficiently successful to warrant John co-founding a company, Corvil, to exploit this intellectual property.

Large Deviation Theory. John and his collaborators had used Large Deviation Theory for Bose systems and in queuing theory. In addition he became interested in the work of Charles Pfister on the foundations of large deviations theory in the context of statistical physics. John encouraged Wayne Sullivan to join the project. The result was a series of papers with applications to probability theory, information theory and dimension theory as well as statistical physics. Two fundamental aspects of the theory are exponential tilting and conditioning. In statistical physics these correspond to interaction potentials and conditioning by observables. The large deviation approach provides a natural treatment of equivalence of ensembles, which relates these two aspects. The ideas also suggest a way to define typical sequences in shift spaces and a consequent interpretation of asymptotic equipartition. Typical sequences may also be used to construct generic points. The Hausdorff dimension of the set of generic points of a measure corresponds to the entropy of the measure. The techniques yield results on sets more general than generic-point sets and apply to extended dimension theory concepts.

J. V. Pulé,
Department of Mathematical Physics,
University College Dublin,
Dublin 4, Ireland
joe.pule@ucd.ie