W F Vinen - a celebration

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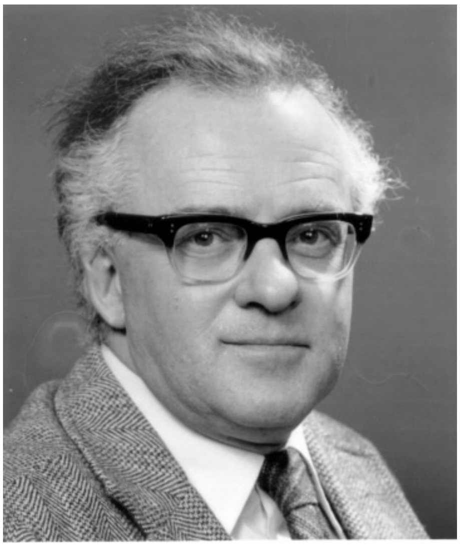

On 29 May 1998, a group of present and past colleagues of Professor William Frank Vinen FRS, known to everyone as Joe, met in Birmingham University for a one-day meeting to mark his retirement from the Poynting Chair in the School of Physics and Astronomy. Although retired in a formal sense, as an Emeritus Professor, Joe continues his research on superfluid turbulence as actively as ever in a number of collaborations worldwide. A collection of papers presented by colleagues with whom he worked especially closely are presented in this Special Issue. They reflect the wide range of his achievements in fields as diverse as superfluid helium, superconductivity, quantum hydrodynamics, turbulence, light scattering and, most recently, the two-dimensional plasma and Wigner crystal formed by ions trapped just below the surface of superfluid helium.

In addition to international recognition as one of the foremost physicists of his generation, Joe Vinen has had a major national influence on physics education at a number of levels. He has spent many years on behalf of the Royal Society and Institute of Physics addressing central issues of science and mathematics education and was largely responsible for the introduction of the four-year physics degree, which is now the norm for a professional physicist. Joe will also be remembered for many other services to the physics community including his chairmanship of the Physics Panel for the last Research Assessment Exercise. Joe's reputation for selfless hard work and his adherence to the highest possible standards in every aspect of his professional and public life have been legendary.

Joe Vinen was born in 1930, the son of a physics schoolmaster, which may have had something to do with his lifelong dedication to both physics and education. From Watford Grammar School he obtained an Exhibition to Clare College, Cambridge, though entry was delayed until 1950 by National Service spent with the RAF at the Headquarters of Flying

Training Command. After a year at Cambridge, he was awarded a Foundation Scholarship and obtained a first-class degree in physics in 1953.

During his undergraduate years he had the good fortune to have both Brian Pippard and David Shoenberg as supervisors. It was therefore not altogether surprising that on graduation he embarked on a PhD in the Royal Society Mond Laboratory at Cambridge, choosing to work on liquid helium. Joe was initially supervised by Donald Osborne, who left after only a year to join Jack Allen in St Andrews before going on to set up the new Physics Department at the University of East Anglia. David Shoenberg then took over as supervisor, though he was more than happy to let Joe develop his own ideas, as he did not really consider himself an expert in liquid helium.

In his first year as a research student, Joe devised an experiment to investigate the propagation of second sound in superfluid helium in the presence of a heat current. This led to the discovery of superfluid turbulence [1], which remains a largely unsolved problem and a continuing lifelong interest for Joe. A Newton Institute workshop on superfluid turbulence is to be held in Cambridge in the year 2000, where he will be presenting his latest theoretical ideas on the subject.

In his second year, Joe teamed up with Henry Hall, who had also entered the Mond at the same time as Joe to work on liquid helium. This mutually stimulating and highly productive collaboration led to their seminal measurements on the attenuation of second sound in uniformly rotating helium [2]. These experiments provided the first convincing evidence for the existence of quantized vortex lines in superfluid helium, which had recently been proposed by Feynman, though the original ideas were first formulated in a famous conference remark by Onsager as early as 1949. Joe's individual research on the attenuation of second sound in a heat current and his experimental and theoretical contributions to the collaborative experiments in rotating helium were written up in a massive double-volume PhD thesis. I still remember these imposing volumes as the most impressive of the many distinguished theses lined up in the library of the old Mond Laboratory.

From the very beginning, Joe's research has been marked by a distinctive blend of careful scholarship, superb experimentation and detailed theoretical analysis. The first problem that he always set himself was to choose an area that addressed really fundamental problems in physics, then to devise novel experiments that would elucidate the essential physics involved, and then to work out, usually from first principles, all the underlying theory.

On the basis of his outstanding research achievements as a PhD student, in 1955 he was awarded a Research Fellowship at Clare College. In 1958 he was appointed to a University Demonstratorship (the equivalent of a Lectureship elsewhere) and to a Fellowship at Clare. This period was to lead to his most exciting contribution to science—the observation of the quantization of the circulation of superfluid $\oint \boldsymbol{v}_s \cdot \mathrm{d}\boldsymbol{r}$ flow in units of h/m [3]. This was the first demonstration of the wave-mechanical properties of any macroscopic body and preceded the related observation of flux quantization in a superconductor by several years.

Joe's demonstration of quantum vorticity in superfluid helium remains one of the most elegant experiments of all time in condensed matter physics. It simply involved observing the changes in the precessional frequency of a vibrating wire as the superfluid helium was rotated, when one or more quantized vortices became attached to the wire. Only someone like Joe, with his deep theoretical insight into the hydrodynamics of both classical and quantum liquids and his experimental inventiveness, could have conceived such a simple but convincing demonstration of quantization on a macroscopic scale.

This was one of the great achievements of the 'string and sealing wax' era of experimental physics in Cambridge, which still has much to commend it. The emphasis then was always on good ideas and innovative experiments, without today's reliance on the latest electronic hardware and computer software. However, times and people change, and today Joe is just as much at home with the latest technology as his students—though there was a time that I still remember, when he much preferred his treasured slide rule to the modern calculators that preceded the PC revolution. The vibrating-wire technique is still widely used to measure the hydrodynamic properties of quantum liquids down to mK temperatures. This is described in the accompanying Special Issue paper on aspects of liquid-^{3}He flow by Henry Hall, who has remained a very close and scientifically stimulating friend, though they never collaborated formally again outside those early Cambridge years.

In 1958 I had the good fortune to join Joe in Cambridge as his first research student. Our joint project was to investigate the transition from ordinary sound to zero sound in liquid helium-3, predicted by the recently published Fermi liquid theory of Landau. The experiment involved developing from scratch: a double-stage demagnetization refrigerator cryostat, a double-feedback system to smooth the 150 A output of a 200 V motor-generator set using some of the first power transistors ever manufactured, a low-field copper NMR thermometer, and a 30 MHz pulsed ultrasonics system based on ex-radar equipment, which mostly worked very successfully. Experiments in those days revolved around home-built apparatus and electronics, oil-filled diffusion pumps, massive mercury-filled glass Toepler pumps to measure high vacuum, and nothing but a Tesla coil and a bottle of acetone and the copious application of GEC-Metrovic red paint to detect and cure the inevitable leaks in the apparatus. Unfortunately, this proved to be a somewhat ambitious project, even for Joe with only me to help him. However, under Joe's excellent tutelage I learned a tremendous amount of physics and we did just succeed in observing the predicted increase in the attenuation of normal sound in a few ml of liquid helium-3, though only down to 50 mK. The prize for observing the transition to zero sound at around 20 mK went to Wheatley in the USA, who had spent many years developing the technology for such experiments.

This experiment marked the beginning of a new level of sophistication in experimental techniques in the Mond Laboratory. With pressure from Bernie Abrahams, a visiting senior research fellow from Argonne, Joe persuaded a local factory to lend us their recently acquired helium leak detector at weekends, which transformed our ability to locate low-temperature leaks. We eventually persuaded the Mond to purchase their own leak detector and, after much resistance, were even allowed to fill our own cryostat with liquid nitrogen and liquid helium. Subsequent generations of Cambridge research students have much to thank Joe for!

In 1962, when he was only 32, Joe was appointed to a Chair in Physics at Birmingham to set up a Condensed Matter Physics Group, and I joined him as a Research Fellow to help establish the low-temperature physics facility. At about that time, the importance of Abrikosov's 1957 paper on type-II superconductors was first beginning to be recognized in the West. This led Joe to initiate what was to become an extensive programme on type-II superconductors in the clean limit, where the electronic mean free path was very much larger than the superconducting coherence length. In a magnetic field, such a system was clearly closely analogous to rotating superfluid helium, the cleanest quantum mechanical macroscopic system that Nature has provided, which is why helium has held such a lifelong attraction for Joe. His interest in the often close similarities between superfluid helium and superconductivity led to a major review on *Macroscopic quantum effects in superfluids* for *Reports on Progress in Physics* [4].

Ted Forgan, who contributes a paper to this Special Issue on vortices in superconductors, and Chris Muirhead, who worked with Joe on both helium and superconductivity problems, both started their research careers as research students on the type-II superconductivity programme. This included a wide range of experimental and theoretical studies on magnetic properties, flux-flow resistivity [5], the Hall effect [6], and transport properties including ultrasonic attenuation and thermal conductivity [7–9]. Joe's very first Birmingham research student, Eddie Warren, went on to be a scientific consultant and a venture capitalist in the USA. He now owns almost as many scientific companies as some of us have published papers! This underlines Joe's view that a graduate training in condensed matter physics provides an excellent training for the outside world, whatever a student's eventual chosen career!

Early in this programme, Joe, in collaboration with Philip Nozières, made a classic contribution to the theory of flux-flow resistivity in type-II superconductors, which was characteristically backed up by supportive experiments [6]. This research drew heavily on his deep insight into the related problem of moving vortices in superfluid helium. Regrettably, the Nozières–Vinen paper, published in *Philosophical Magazine*, was largely ignored by the superconductivity community. In contrast, the *Physical Review Letters* contribution by Bardeen and Stephen on the same topic, but neglecting the motion of the flux line relative to the supercurrent, has been almost universally cited. However, in recent years the importance of the Nozières–Vinen paper has been properly recognized, particularly in relation to transport properties in clean type-II superconductors and the related reversal in sign of the Hall effect in the cuprate high-temperature superconductors.

As the selected bibliography at the end of this introductory appreciation demonstrates, Joe has always been a very strong supporter of the traditional British journals. He has always been reluctant to publish in *Physics Review* or *Physics Review Letters*, where his research might well have received wider international recognition outside the immediate liquid-helium community. However, he would rightly claim that research of quality will always be recognized wherever it is published, and this has ultimately proved to be the case.

Following the type-II superconductivity programme, Joe returned to his first love, superfluid helium, and in the 1970s initiated a programme on the physics of the helium λ-point phase transition. At that time, thermodynamic measurements had verified critical scaling behaviour to within a fraction of a microdegree of the transition temperature. However, much less was known about the dynamical behaviour. With Michael Vaughan, Joe therefore set out to observe Brillouin scattering from first and second sound in the superfluid and from sound and temperature fluctuations in the normal state [10, 11]. These measurements disproved an assertion made by Fabelinskii, in his famous textbook on *The Molecular Scattering of Light*, that such doublets would never be observed. Michael Vaughan has contributed a paper to this Special Issue giving an account of some of these early measurements and describing how Doppler laser spectroscopy techniques similar to those developed for the helium λ-point experiments are now widely used to study turbulence in air, especially in relation to aircraft safety. Additional λ-point measurements and their detailed theoretical interpretation were published in a major review paper in *Advances in Physics* [12], which included important input from Joe's then research student David Hurd. Joe took great pride in basing the theoretical work on 'simple' physical arguments rather than relying on renormalization group theory, which was very much the 'flavour of the time', but which he believed could sometimes obscure the underlying physics.

Joe next returned to the problem of the nucleation of quantized vortices in superfluid helium. This was an important problem that Joe had identified much earlier in his lectures at a *Varenna Summer School on Superfluid Helium* in 1963 [13]. This led to major publications in *Philosophical Transactions of the Royal Society* [14] and *Proceedings of the Royal Society* [15], with important computational input from Chris Muirhead and experimental data from Russ Donnelly in Oregon. Their predictions concerning the nucleation of vortex rings by moving ions, including both thermally activated and quantum mechanical tunnelling processes, were subsequently confirmed with remarkable accuracy in later measurements by Peter McClintock at Lancaster, who has written a review of the subject for this Special Issue. In Joe Vinen's view, his theoretical work on the nucleation of vortices in superfluid helium is the most important of all of his scientific achievements at Birmingham.

The success of these theoretical studies encouraged Joe to set up his own experimental programme to investigate vortex nucleation by moving negative and positive helium ions held just below the surface of superfluid helium by an electrostatic ion trap. The initial programme involved Carlo Barenghi as a research fellow and Chris Mellor as a research student; they have contributed papers on superfluid quantum turbulence and on quantum liquids and solids in two dimensions to this commemorative Special Issue. Joe recognized that, in addition to allowing a thorough investigation of the mobility of trapped ions down to around 10 mK [16], such experiments could also be used to investigate the properties of an extremely well-defined classical two-dimensional plasma of charged ions. This led to the first observation of the Wigner crystal in such a system involving the use of surface ripplons of known wavelengths to perform novel diffraction studies of the crystal structure [17]. These experiments included detailed investigations of the melting, plastic deformation and recrystallization of the Wigner crystal [18] and the discovery of a new class of magnetoplasmon, associated with propagating modes around the edge of the plasma [19]. Ladislav Skrbek, a senior research fellow, who made a major contribution to the success of this project, has now joined Russ Donnelly in Oregon and has contributed a paper to this Special Issue on superfluid-helium wind tunnels for aerodynamic research at very high Reynolds numbers. Joe's last two research students, Chris Pakes and Phil Elliott, were particularly talented and hard-working, and their own account of the helium-ion experiments is also included here. For Joe the helium-ion project, with its strong interplay between experiment and theory, and the intense collaboration that he enjoyed with everyone involved, was a particularly satisfying experience. This project was certainly a fitting culmination of his many outstanding achievements, while leading the Condensed Matter Group in Birmingham.

In parallel with his research on the two-dimensional helium-ion plasma, and all of his other activities on behalf of the physics community, Joe Vinen somehow also found time to take an active research interest in high-temperature superconductors. Not surprisingly, he was primarily interested in flux-line dynamics and the physics of the various vortex glass and liquid states. At the time of the discovery of the cuprate superconductors in 1987, he gave me his strongest possible support in setting up the Birmingham research initiative on high-temperature superconductivity, which established a well-supported, major interdisciplinary programme in this area.

Although Joe supervised several research students on various aspects of the cuprate superconductors, he deplored the 'hype' associated with many of the activities and the superficiality of much of the published research. Furthermore, quite unlike liquid helium with its beauty and perfection, the cuprate superconductors were dirty in every sense of the word—even theoretically, where after a dozen years we still have no satisfactory microscopic theory. The field also involved far too many people, many attempting the same experiments, and with too much emphasis on applications rather than fundamental physics for Joe's natural inclinations. Nevertheless, despite his natural antipathy, he still made a number of valuable contributions to the subject [20] and provided very valuable intellectual input and support to all of us involved in research in this area. As an example, he was one of the first to recognize the importance of vortex nucleation at the edge of a sample in determining the bulk transport properties, long before such ideas became widely accepted.

Such is his enthusiasm and dedication to physics that Joe will never retire in anything other than a formal sense. As an Emeritus Professor, he continues research on an almost full-time basis. This includes collaborations with several groups in the USA and Japan, and with Russell Donnelly in particular [21], which have led to many enjoyable scientific visits to Oregon. ‘Russ’ has celebrated their lifelong friendship and collaboration by contributing an extended review on aspects of superfluid turbulence to this Special Issue, even though he was sadly unable to be present at the meeting itself because of illness. Einstein once remarked that turbulence would remain one of the major unsolved problems of physics, long after all of the important problems in quantum mechanics had been solved. For Joe, this represents the ultimate scientific challenge; it is certainly worthy of his talents in what we hope will be a long and scientifically productive retirement!

Joe’s research has attracted many national and international honours. He became a Fellow of the Royal Society in 1973, and together with Henry Hall was awarded the Simon Memorial Prize in 1963. In 1978 he was awarded the Holweck Prize of the Institute of Physics and French Physical Society and in 1980 was recipient of the Rumford Medal of the Royal Society.

At Birmingham, Joe has been an inspiring leader of the Condensed Matter Group for 36 years. In 1973 he succeeded Philip Moon as Poynting Professor and became head of the then Physics Department for eight years at a difficult time when the first rounds of university cuts were beginning to bite. Nevertheless, he was able to promote a number of important new research initiatives, like the pioneering solar seismology programme of George Isaacs. One of the reasons Joe first accepted a Chair at Birmingham was the presence at that time of the very distinguished Theoretical Physics Group led by Peierls, who unfortunately for Birmingham left soon afterwards for a Chair at Oxford. Many years later, Joe was instrumental in establishing a new Solid State Theory Group at Birmingham, led by Mike Gunn, which is now one of the largest in the country.

Joe was an outstanding lecturer at both undergraduate and postgraduate levels and, of course, at conferences. He was a paragon in the careful preparation of his lectures and had a major influence on the development of undergraduate courses throughout his time at Birmingham. He fought a continuous battle in trying to encourage students to think and learn for themselves and to understand basic physical principles rather than to accumulate sophisticated yet undigested facts.

Outside Birmingham, Joe’s influence on physics research and education has been far reaching. In education, this has included a long association with the Open University, first as a member of the committee set up by Keith Joseph, the then Secretary of State at the Department of Education and Science, to advise on the allocation of resources to the OU. Subsequently, the DTI appointed Joe as an assessor for the OU solid state physics module, with a brief that included assuring the Minister that the accompanying television programmes contained no Marxist propaganda! You can be sure that his influence on the course content went far deeper than that. He has been a long-serving member of the OU Council and its Strategy, Planning and Resources Committee, in addition to being a member of several other of their *ad hoc* groups.

Joe served for many years in various capacities on the Science Research Council. This included terms as Chairman of the Physics Committee, and membership of the Science Board and of various subject committees. These activities in turn led to membership of the University Grants Committee, where he was involved in the first Research Assessment Exercise. Joe was chairman of the Physics Panel for the last Research Assessment Exercise in 1996. His reputation for integrity and confidentiality has always meant that his colleagues at Birmingham were often the last to learn about the recommendations of any such panel. Joe brought to such exercises the same very high standards that he expected in his own research. This might explain why there were only two five-star physics departments in the whole country. Comparability of standards across subject areas must clearly be an issue for the next assessment exercise.

Joe spent two periods as a member of the Council of the Institute of Physics. During the first he pressed for an enquiry into the health of university physics, which led to the Institute of Physics report *Physics in Higher Education*. This was an important contribution to the subsequent 1988 Edwards Report to the UGC on *The Future of University Physics*. In turn, this led to the Institute of Physics report on *The Future Pattern of Higher Education in Physics*, produced by a working party chaired by Bob Chambers from Bristol. In these reports, it was recognized that changes in pre-university schooling in mathematics and physics and the sheer growth in material that any professional course in physics was expected to cover meant that the three-year undergraduate BSc course was no longer providing an adequate grounding for intending professional physicists. Furthermore, there was an increasing disparity in the content of UK and European Physics degrees, which threatened to disadvantage UK students' career prospects, as we moved towards closer relationships with our European partners. It was therefore recommended that a four-year master's degree course should become the norm for those wishing to be professional physicists, and that such courses should be redesigned to encourage students to achieve a deeper understanding of physics, which was just as important an objective in Joe's view.

It became Joe's job to persuade the then Department of Education and Science, the universities and their physics departments to provide the resources to achieve this. His success in this Herculean task has transformed the pattern of undergraduate physics teaching in the UK. The four-year degree has proved to be very successful with academics and students alike, despite the additional year and additional cost of their training. Retaining students for an additional year has also helped many physics departments to survive financially, despite the continuing fall in undergraduate numbers, as students move to less scientifically demanding subjects.

Joe has also served on the Council of the Royal Society and has represented the Society as Governor of Rugby School and of Coventry University (formerly Lanchester Polytechnic). Other public services on behalf of the physics community have included a period as chairman of the Standing Conference of Professors of Physics and many years as a member of the Commission on Low Temperature Physics of the International Union of Pure and Applied Physics. For a number of years he has also been a member of the Department of Trade and Industry advisory panel responsible for overseeing the work of the National Physical Laboratory.

Few physicists can claim to have made such an impact in research, education and public service to the community. Professor W F Vinen FRS has been one of the most outstanding UK physicists of the latter half of this century and the four-year physics degree will provide a permanent legacy to mark his many contributions to the physics community. We wish him a long, fulfilling and happy retirement.

Finally, I would like to express my immense personal gratitude to Joe, with whom I have worked all my life, starting my research career as his first research student in Cambridge through to my current period as his successor as head of the Condensed Matter Group in Birmingham. He has been a constant inspiration in terms of his knowledge and understanding of physics and has given me great personal support. I must also add my gratitude to Susan, his wife, who has been a great strength and provider of selfless support to Joe throughout his career. I too have been the beneficiary of her support. I remember in particular the regular midnight sandwiches, when we both worked late into the night on our early ^{3}He experiments. Then there were the hazardous drives every weekend between Birmingham and Cambridge to finish my PhD experiment, with Susan often leading our car with a torch through the freezing fogs of the winter of 1962. Many generations of students and staff at Birmingham have enjoyed similar support and hospitality from Joe and Susan, well beyond the call of duty. On behalf of all of his colleagues and students in the Group over the last 36 years, I thank them both.

The collection of Special Issue papers appearing here provides a fitting testament to Professor Vinen's scientific achievements and his major influence on many areas of research over the last 40 years. Happily, it includes papers from a large number of his colleagues with whom he established a particularly close working relationship. Their respect and affection for Joe is reflected by the willingness with which they all agreed to write special papers in his honour. The selected bibliography of Joe Vinen's publications below highlights his most important scientific achievements, which we have attempted to summarize in this introductory appreciation.

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