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OBITUARY

EDWARD MAITLAND WRIGHT 1906–2005

Sir Edward's working life was full and long. He supported himself from the age of fourteen until he retired as Principal and Vice-Chancellor of the University of Aberdeen at the age of seventy. He had been elected to the Chair of Mathematics there at the early age of twenty-nine. While under his guidance as Principal, the university went through a vigorous expansion, with many new buildings and appointments. He had enormous affection for Aberdeen, both the city and its ancient university. When he retired, he stayed on in Aberdeen until at the age of ninety he left to live with his son in Berkshire. He died peacefully on 2 February 2005, a few days before his 99th birthday, and is buried in Oxford. He particularly enjoyed the company of his grandchildren, Jane, Lucy, Vicky and Edward, and was delighted when he became a great-grandfather.

He was born on 13 February 1906 in a village just outside Leeds. Initially, the family was highly prosperous. His father owned a soap factory making 'Wright's Washall Soap'. Unfortunately, when he was three years old, his father's business collapsed. His parents separated and he and his mother moved south. She was a skilled musician and music teacher who obtained jobs at boarding schools where she could — for a reduction in salary — have her young son living with her. At the age of fourteen he became independent by working as a 'pupil teacher' at a small preparatory school in Woking. His duties included playing football with the pupils and teaching them French! He was well educated in classics and modern languages but, until the age of fourteen, had not come across any mathematics except arithmetic. He was introduced to algebra, and became hooked on mathematics from then onward.

When he was sixteen he was working as a teacher of French at a school in London, taking evening classes in physics at Woolwich and teaching himself mathematics. A school inspection took place. The inspector reported that Edward Wright was far too young for the post he was occupying. He was immediately sacked. He then got a teaching job at Chard Grammar School in Somerset. Since he had no access to laboratory facilities, he gave up on experimental physics but re-doubled his efforts in teaching himself mathematics. At that time it was possible to take a University of London degree as an external candidate, that is, without any requirements to attend courses. Working on his own in Chard, he taught himself for a BSc in Mathematics, achieving First Class Honours. One of the other teachers was a graduate from Cambridge who said: "Oh, a London degree is only equivalent to entrance scholarship standard for Oxford and Cambridge." Nettled by this, he investigated Oxford and Cambridge and found only one college in either university which had a scholarship open to someone over the age of nineteen. This was Jesus College, Oxford, which had one scholarship not restricted to age or subject. He competed for the scholarship and won it.

His period at Oxford was happy and fruitful. He won the Junior Mathematics Prize as an undergraduate, and the Senior Mathematics Prize as a postgraduate. He met his future wife, Phyllis, a student of English at St Hilda's and cox of the Oxford women's eight, marrying her in 1934. He became a research student of G. H. Hardy. He obtained the first-ever Junior Research Fellowship (at that time known, somewhat strangely, as a 'research lectureship') awarded by Christ Church. Joining the University Air Squadron, he learned to fly.

At Hardy's urging he spent a year in Germany at Göttingen. This was just before Hitler came to power, and Göttingen was still one of the major mathematical centres in the world. He was well treated in Germany, but came home convinced that another war was inevitable. At that time Churchill and his supporters, who urged re-armament, were in a small minority and were decried as 'warmongers'. Lord Cherwell (subsequently scientific advisor to Churchill) was a professor of physics at Oxford and had rooms in Christ Church. Because of their shared political views on the dangers of appeasement, Edward Wright became friendly with both Cherwell and R. V. Jones. Arising from these connections, during the war years he was seconded from his chair in Aberdeen to work in Scientific Intelligence at MI6 headquarters in London.

He greatly enjoyed doing research in mathematics, and was the author of some 140 papers. Apart from a gap during the war, he published steadily from 1930 until 1981. (For many years, his research was supported by the US Army through a succession of research contracts.)

In collaboration with G. H. Hardy he wrote *An introduction to the theory of numbers*, which is still in demand after over sixty years in print. After meetings of the London Mathematical Society in Piccadilly, Hardy and he would have dinner together at the Trocadero. It was during one of these dinners that the book was first planned. Their method was for each to write different chapters and then revise and criticise the work of the other until the revisions converged to an agreed version. Sadly, Hardy died before a second edition was needed. Edward Wright prepared all the subsequent editions, from the second to the fifth. The book has been translated into many languages, including Japanese.

Sir Edward had many honours and distinctions, but wore them lightly. These included honorary degrees from St Andrews, Strathclyde and Pennsylvania. He was a Fellow of the Royal Society of Edinburgh, and was awarded its Macdougall–Brisbane Prize in 1952. He was the longest-serving member of the London Mathematical Society, and won its Senior Berwick Prize in 1978. In the same year he was awarded the Gold Medal of the Order of Polonia Restituta of the Polish Republic. He was the longest-serving Honorary Fellow of Jesus College, Oxford, having been elected at the same time as Harold Wilson.

He was a big man, both intellectually and physically: over 6 feet 4 inches, broad-shouldered and built like the rowing man he had been in his youth. His early struggles and triumphs make it clear that he was unusually determined and exceptionally intelligent. But those who knew him best will remember him most strongly for his kindness, his generosity and his sense of humour.

He is survived by his son, Professor J. D. M. Wright. I thank John Wright for much help in the preparation of this notice, and for permission to use the photograph. I thank also Professors G. E. Andrews, R. C. Corless and D. J. Jeffrey and Dr J. Sheehan for their contributions on Sir Edward's mathematical work.

Mathematical work

Graph theory [*contributed by J. Sheehan*]

As stated elsewhere, Edward Wright was the Principal and Vice-Chancellor of the University of Aberdeen from 1962 until his retirement in 1976. He became interested in graph theory during this period, and often survived tedious committee meetings by furthering this interest.

As a consequence of a mutual interest in graph theory, I got to know him fairly well. He was unfailingly kind, generous, courteous and warm-hearted to me, as to so many others.

In the period from 1968 until 1985 he published some 35 or so papers on graph theory. He was mainly interested in enumerating unlabelled graphs with various constraints such as the number of edges, the connectivity and the occurrence of large cycles (including Hamiltonian cycles). In [**125**], he also extended some classical results of Erdős and Rényi ⟨**4**⟩ on the 'growth of random graphs'.

I would now like to give a tiny flavour of his work. Wright [**104**] obtained a result on the enumeration of unlabelled graphs which, as Béla Bollobás says ⟨**3**, **4**⟩, is both important and deep.

Let U_q and L_q be, respectively, the number of unlabelled and labelled graphs with n vertices and q edges. Thus

$$L_q = \binom{N}{q}, \qquad \text{where } N = \binom{n}{2}.$$

Each unlabelled graph G can be labelled in exactly $n!/|A(G)|$ different ways, where $A(G)$ is the automorphism group of G. Wright proved [**104**] that

$$U_q \sim \frac{L_q}{n!}$$

if and only if

$$\frac{2q}{n} - \log n \to \infty \qquad \text{and} \qquad \frac{2(N-q)}{n} - \log n \to \infty. \tag{$*$}$$

The proof is beautiful in its simplicity. Wright showed that in counting the unlabelled graphs on n vertices and q edges using Pólya's generating function ⟨**8**⟩, the first coefficient (corresponding to the identity permutation) essentially dominates all the other coefficients. He then applied his awesome asymptotic skills to obtain the result.

What is even more interesting is what happens when $(*)$ does not hold, when more of the automorphisms play a role. In [**117**] he considers this problem, and again obtains powerful results. He uses the same method [**104**], but now shows that the first M coefficients essentially dominate all the other coefficients, where M is a function of n and q. This result shows that the relation between the asymptotic behaviour of labelled and unlabelled graphs is very far from dull when $(*)$ is not satisfied. Of course, his contribution to enumerative graph theory was enormous; this represents only a small sample of his work.

Number theory [*contributed by G. E. Andrews*]

Without doubt, number theorists will know Wright best from the phrase 'Hardy and Wright'. *An introduction to the theory of numbers* is *the* classic text on elementary number theory. In his review of the first edition, L. J. Mordell provided this prescient description ⟨**7**⟩.

> The authors have spread their nets far and wide in gathering material and their haul is a very nice one indeed. It is really surprising what an immense storehouse they have filled. There is sufficient variety in it to satisfy the most catholic taste and to cater for the reader in all his moods. He may go through the book from cover to cover, or study a chapter here and there, or dip in now and then for a pleasant morsel. In lighter moments he may turn to the theory of the game of Nim, while on more austere occasions he may study the question of Euclidean algorithms in algebraic fields, or the Rogers–Ramanujan identities in the theory of partitions ... The book is sure to have a long and successful life.

Over the years, as the number of editions has extended to five, others have noted the magnificence of 'Hardy and Wright'. Pierre Samuel ⟨**10**⟩ describes it as 'profound and beautiful; shows a remarkable aesthetic sense in the choice of material'.

Now, nearly seventy years after its first appearance and more than twenty-five years after the fifth and final edition, we find numerous reviews on the world wide web; even in the twenty-first century, phrases such as 'this is a must have classic!' are still being used.

More than a third of Wright's papers were on number theory. Much of his pre-war work related to Diophantine problems such as those involving sums of squares, or more generally Waring's problem and especially the Tarry–Escot problem. The latter problem asks for solutions of the system of k equations:

$$a_1^h + a_2^h + \ldots + a_S^h = b_1^h + b_2^h + \ldots + b_S^h, \qquad 1 \leqslant h \leqslant k.$$

His final paper on the topic [**88**] provides a good example of the methods that he used to improve the estimates on the number of solutions.

Wright, along with the rest of the number theory community, was captivated by the Erdős–Selberg elementary proof of the prime number theorem. Wright's primary contribution [**45**] was to produce a revision of Selberg's proof that, according to the review ⟨**11**⟩, tended to elucidate Selberg's argument by replacing some sums with integrals. Wright included this version of the prime number theorem in the third and subsequent editions of 'Hardy and Wright'.

Nearly half of Wright's number theory papers are devoted to the theory of partitions. Here Wright was truly a pioneer. He engaged some very difficult problems [**9**, **91**], and he developed asymptotic methods that have really been path-breaking.

His paper on partitions into kth powers is truly exciting, very deep and — sadly — neglected. In ⟨**2**⟩, it is remarked that "Wright's third paper [**9**] on partitions IS UNIQUE in the history of this subject. Its starting point and fundamental philosophy are different from anything that has come before or since." In this paper, Wright considers

$$\sum_{n=0}^{\infty} p_k(n) x^n = \prod_{l=1}^{\infty} \left(1 - x^{l^k}\right)^{-1}.$$

Thus $p_k(n)$ is the number of partitions of n into kth powers. The instance of $k = 1$ is Euler's ordinary partition function. Hardy and Ramanujan ⟨**6**⟩ (with a subsequent boost from Rademacher ⟨**9**⟩) obtained a convergent asymptotic series for $p_1(n)$ (cf. ⟨**1**⟩). Their method relies heavily on the fact that when $k = 1$, the generating function is essentially the reciprocal of the Dedekind eta-function, a modular form. When $k > 1$, the generating function is no longer a modular form, a substantial obstacle to further progress. To his credit, Wright constructs a transformation theory of the generating function for all k. From this he is able to obtain the dominant asymptotic term for $p_k(n)$ with an error term that is of an exponentially lower order. In ⟨**2**⟩, an account is given of the many appealing research questions raised by [**9**].

As mentioned earlier, Wright's many contributions to the asymptotic theory of partitions have paved the way for much further work. For example, he found the generating functions for plane partitions to be even more recalcitrant than that for kth powers. Wright was able to show [**2**] that the number of plane partitions of n is asymptotic to

$$(\zeta(3)2^{-1})^{1/36} n^{25/36} \exp(3.2^{-2/3}\zeta(3)^{1/3} n^{2/3} + 2C),$$

where ζ is the Riemann zeta function and

$$C = \int_0^\infty \frac{y \log y}{e^{2\pi y} - 1} dy.$$

The form of this answer conveys how subtle the underlying analysis is.

Later in his career, Wright applied his asymptotic methods to partitions into multipartite numbers. Here one considers k-tuples of integers, so-called 'multipartite numbers'. The relevant generating function is now

$$\prod_{n_1, n_2, \ldots, n_k \geqslant 1} \frac{1}{1 - X_1^{n_1} X_2^{n_2} \ldots X_k^{n_k}}.$$

Thus one now has k variables instead of just one, and the analytic difficulties are magnified accordingly. However, in a series of papers concluding with [**55**], [**59**] and [**63**], Wright obtains substantial asymptotic theorems.

While his asymptotic work contains his most profound contributions to the theory of partitions, Wright also made astute observations and contributions to the combinatorial side of partitions, especially partitions of multipartite numbers. He provides an ample survey of these accomplishments in [**83**].

To summarize, we must acknowledge that Wright's universal recognition by number theorists will undoubtedly be for his collaboration with G. H. Hardy that produced *An introduction to the theory of numbers*. However, it is to be hoped that a re-evaluation of his partition-theoretic research will make clear his pioneering role in asymptotic methods.

Complex function theory [*contributed by R. C. Corless and D. J. Jeffery*]

A number of Wright's papers, written between 1947 and 1958, led in 2002 to a new function (a special function in the mathematical sense) being defined and named after him: the 'Wright omega function' ⟨**5**⟩. Fortunately, he was able to learn of this naming, and take pleasure in it. In 1959, he had published 'Solution of the equation $ze^z = a$' [**64**, **65**], a paper which had grown out of earlier papers he had written. In the 1947 paper, 'Iteration of the exponential function' [**29**], Wright needed the fixed points of the iteration of $f(x) = ce^x$. For these, he had to solve the equation $x = ce^x$. Later, the equation came to Wright's attention again as a result of his 1955 paper on difference–differential equations [**51**]. Simple transformations take either equation to $We^W = z$, and then this equation defines a function $W(z)$. Independently of Wright, this function had been defined and implemented in the MAPLE computer algebra system in the early 80s as plain W; then in the early 90s, it was named the 'Lambert W function'.

However, as Wright clearly saw, the function W is an awkward one to study, because it is multivalued. He anticipated modern notation by labelling the branches with an integer subscript. In current notation, the branches $W_n(z)$ must be described. Wright's key observation was to see that if he switched to considering the equation (again changing his notation to the modern one)

$$\omega + \ln \omega = z,$$

and thus defining the function $\omega(z)$, then the multiple branches of W could be economically described using the single-valued function ω together with the relation

$$W_n(z) = \omega(\ln z + 2\pi i n) \qquad \text{almost everywhere.}$$

Because of his insight, the function $\omega(z)$ was named in his honour ⟨**5**⟩. There is one difference between the Wright ω function as now defined, and the function defined by Wright in his 1959 paper. As he showed, the equation $\omega + \ln \omega = z$ must be studied on the cut z-plane, because the lines $z = u \pm \pi i$, for $u \leqslant -1$ do not give unique solutions for ω. The Wright ω function, however, is defined so that $\omega(z)$ is single-valued at all points z, although the lines $z = u \pm \pi i$, $u \leqslant -1$, remain lines of discontinuity. The technical details are available m the paper proposing the name ⟨**5**⟩.

The original papers of Wright remain a joy to read, both for the completeness with which he had seen the solutions to the equations, and for the applications which led him to the need for solving them.

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