Professor W.L. Edge

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OBITUARY

PROFESSOR W. L. EDGE

1904–1997

William Leonard Edge was born on 8th November 1904 in Stockport, Cheshire. His father, William Henry Edge, was a local headmaster and his mother Christina was also a teacher; there was one brother. He was educated at Stockport Grammar School, leaving there in 1923 with an Entrance Scholarship to Trinity College, Cambridge. A treasured item in his library dating from that period provides a glimpse of things to come: a copy of *Algebra of Invariants* by J. H. Grace and A. Young (Cambridge, 1903), given by the school as an "Open Scholarship Prize". It is a famous treatise but hardly expected reading for one who has just left sixth form! He was to refer to this source on many occasions in his researches. Graduating BA in 1926, he was elected a Research Fellow of the College in 1928, in which year he was also an Allen Scholar of the University. Proceeding to the MA in 1930 he was awarded the degree of Doctor of Science in 1936.

Edge's research was carried out under the supervision of Professor H. F. Baker whose seminars on geometry, held at 4.15pm on Saturdays, were known informally as the Baker tea-parties. Baker's flourishing school of geometry, then at its peak, included many who became great names in the field. H. S. M. Coxeter, J. A. Todd, P. du Val, to mention but three, were Edge's contemporaries. He was a man who formed firm friendships and who maintained an extensive correspondence; these and other associates of the time influenced his work for the rest of his life.

In 1932 he was appointed to a lectureship at the University of Edinburgh under Professor E. T. Whittaker and settled readily to a noteworthy career in teaching and research. With characteristic loyalty, however, he retained a life long interest in, and links with, his old School and College. In Edinburgh, life was congenial. He was able to indulge his two great loves of music and the countryside, especially hill-walking. Further warm friendships with Whittaker, A. C. Aitken, H. W. Turnbull and other distinguished mathematicians of the time were forged. He had a marked tendency to hero-worship, and affectionate reminiscences of his friends and colleagues loomed large in his conversation, especially in later life. This was not merely an endearing social trait but, in parallel with an enormous respect for great mathematicians of yesteryear such as Cayley, Sylvester, Salmon and the many continental geometers, was to inform and shape his whole mathematical development. His knowledge of the writings of these predecessors can only be described as encyclopaedic. The highly individual style of writing, too – a little old-fashioned and pedantic, but very clear – can probably be traced to those sources.

Edge's lecturing spanned the whole range from the First Ordinary class to Honours work, particularly of course in Geometry. The lectures were full of insight but maintained traditional standards of manipulative skill and geometric intuition; consequently they were often found demanding. The routine of "definition, theorem, proof" was not for him, either in teaching or research. But his classes brought yet more friendships which he cherished down the years. He was always delighted to hear of former students' achievements. A certain formality was nevertheless retained. He was "Leonard" to his family but friends and colleagues would not have addressed him by christian name; affection, however, was not diminished by this dignity. Detailed administration was not to his liking, but fortunately the department had, in David Gibb and later Ivor Etherington, others who excelled at that task. Characteristically, though, he did keep the file of pupils' post-graduation records. His eventual promotion from Reader to a personal chair in Geometry was richly deserved and gave him great pleasure. He retired as Professor Emeritus in 1975.

In retirement he remained outstandingly active in research. Unfortunately physical infirmities began to trouble him. Particularly cruelly, knee problems caused difficulty in walking and he became progressively more deaf. A bachelor, he finally moved from lodgings to Nazareth House at Bonnyrigg. There, largely confined to his room but still sharp of mind, reading Salmon and the other masters, he continued to receive much correspondence and many visitors, some highly distinguished. His last three papers were published from there, the final one remarkably at the age of 90. Unhappily his eyesight eventually failed too and he died peacefully in the devoted care of the Sisters on the 27th September 1997.

A most memorable attribute of the man was the deep, resounding voice. Among his enormous fund of stories he would tell of meeting a distinguished friend in Cambridge one afternoon. On taking Edge home the host called out to his wife, "I've brought Dr. Edge in for tea, dear" to which the reply was, "So I hear". He had too a fine singing voice, and conducted the E.U. Catholic Chaplaincy choir for many years, keenly maintaining the tradition of Gregorian chant. On a more earthly plane he was a man of vigorous appetite; many of his tales included references to memorable meals. His appreciation of food seems to date back to Cambridge days – among his papers was a collection of menus of college and other feasts, some as long ago as the 20's, and very appetising they are.

From the outset of his career in Edinburgh, Edge was a member of the Edinburgh Mathematical Society. He served it as President and for many years as Librarian. He was a most regular attender at meetings, afterwards always ready with incisive comment on the quality of the lecture and of the tea. A particularly staunch supporter of the St Andrews Colloquium, he was made an Honorary Member of the Society in 1983. He had been elected a Fellow of the Royal Society of Edinburgh in 1934.

It would be fair to say that "W. L. E" was not entirely a creature of the twentieth century. His role models and his interests derived from an earlier period. He disliked change, particularly in colleges, universities and the Catholic Church. He was never a motorist and spurned lifts until the decline in rail transport and his own impaired mobility rendered these a necessity. He treated radio and television with disdain. The decline in geometry in the syllabus of schools and universities distressed him. But his loyalty to his friends remained steadfast and his passing is felt to be the end of an era, and the loss irreplaceable.

The mathematical work

This survey of the mathematical legacy of W. L. Edge contains a little detail on one or two topics to show the flavour of the work, but only by reading the papers does one obtain a full appreciation of the wealth of information and the loving attention to detail which they contain. The bibliography is complete as regards the book and research papers and probably the obituaries, which are charming; a few book reviews and an article in the Cambridge magazine *Eureka* have not been detailed.

Edge's first publication was the book [**R**] based on his Trinity Fellowship dissertation. This is a systematic classification of the quintic and sextic ruled surfaces of three-dimensional projective space [3], the quartics having been dealt with by Cremona in 1868. It is a major undertaking but is probably not the work for which he will be best remembered. The first paper [**1**] is concerned with a similar topic, the quartic developable in [3] being considered as a projection of a rational quartic ruled surface in [5].

One recurrent theme in the papers is that of linear systems of quadrics, and particularly nets of quadric surfaces. Again the origins are classical (Hesse, 1855). The net of quadric surfaces in [3]

$$\lambda_0 Q_0 + \lambda_1 Q_1 + \lambda_2 Q_2 = 0 \tag{1}$$

contains ∞^1 cones whose vertices are the points of a sextic curve ϑ, the Jacobian curve of the net. This space curve is in (1,1) birational correspondence with a plane quartic curve δ which is general, and so of genus 3, when the net is general. If P is a point of ϑ then the polar planes of P with respect to the quadrics (1) have in common a line which meets ϑ in three points – it is a *trisecant* of ϑ; the trisecants generate a scroll of order 8. The quadrics (1) have in common 8 base points whose joins in pairs are chords of ϑ. In the plane with homogeneous coordinates $(\lambda_0, \lambda_1, \lambda_2)$ the points of a conic yield an ∞^1 subsystem of the quadrics (1) whose envelope is a quartic surface having nodes at the 8 base points and called by Cayley "octadic". In [**3**] this situation is examined in detail and octadic surfaces with additional nodes are studied; [**7**] is a sequel. Consideration of the trisecants of ϑ yields properties of δ, especially in- and circumscribed triangles. The next paper [**4**] deals with nets in higher dimensions while [**8**] and [**10**] extend the theory of the Jacobian to [4]. Noteworthy specialisations of general situations were always a fascination to Edge. In [**12**] the case when the base points form two Möbius tetrahedra is considered and furnishes information on the Plücker quartic surface; now the plane quartic δ breaks up into two conics. Related to this is the contact net [**24**]. The culmination of these investigations is the series of "Notes on a net of quadric surfaces" [**15, 16, 18, 19, 21**] The first four discover many more loci associated with the net and the last handles yet another fruitful specialisation. Brief returns to the same theme were made [**76**] and [**80**].

If instead of (1) we consider quadrics through just six points the locus of vertices of cones becomes the quartic Weddle surface, related in turn to the famous Kummer surface [**12, 31, 42, 54**]. One of the favourite techniques of "Bakerian" geometry was the study of configurations by means of projection from a figure in higher dimensions. This was applied skilfully to the Weddle surface in [**42**], whilst [**6**] contains a nice self contained illustration of the method.

Quartic curves and surfaces were of continuing interest. He had the teacher's eye for the instructive and structurally rich special case and delighted in showing how a procedure which is known to be theoretically possible can actually be carried out on a suitable example. So for instance the quartic form $x^4 + y^4 + z^4$ is skilfully tackled in [**17**]. As mentioned in the first part of this memoir the work is always informed by close knowledge and critical review of the nineteenth century writings. A key object in this area in the Veronese surface in [**5**] defined parametrically by

$$(x_0, x_1, x_2, x_3, x_4, x_5) = (y_0^2, y_1^2, y_2^2, \tau y_1 y_2, \tau y_2 y_0, \tau y_0 y_1) \tag{2}$$

with $\tau = \sqrt{2}$; it has many remarkable properties. The introduction here of τ is a typical touch of Edge's algebraic genius. It corrects and greatly improves the original treatment by Veronese, of whom Edge writes [**20**], "his geometrical insight enabled him to give the correct results without depending on any algebra to discover them, while he was so sure of the geometry that he must never have troubled to subject his algebra to any test". The first part of this sentence could well be applied to Edge himself; the second certainly could not. His papers contain various similar gentle but stylish rebukes to other authors whose work was not considered sufficiently insightful or geometrical. A quartic polynomial in y_0, y_1, y_2 can be regarded in various ways as a quadratic in the squares and products on the right-hand side of (2); this leads to Sylvester's "unravelment" studied in [**23**]. The famous Klein quartic

$$xy^3 + yz^3 + zx^3 = 0$$

makes an appearance in this light in [**25**], where A. B. Coble comes in for criticism: "his statement that two covariant conics coincide becomes merely an example, albeit a highly exalted one, of the conclusion that zero is equal to zero, for Klein's quartic has no covariant conics". Again the quartic

$$\alpha x^4 + \beta y^4 + \gamma z^4 = 0$$

associated with the name of Dyck, has a special configuration of its 16 "non-flecnodal" bitangents. Edge **[26]** recognised the appearance of such figures, and therefore of Dyck curves, in one of his favourite hunting-grounds, the Klein configuration of six linear complexes mutually in involution. From this, referring back to **[21]**, he can derive the Maschke quartic surfaces, invariant under a collineation group of order 1920; the algebra is elegant. The papers **[28]** and **[31]** are sequels, while **[30]**, also inspired by Klein, provides more algebraic virtuosity.

The study of quartics rich in self-collineations led inexorably to the detailed contemplation of certain finite groups of exceptional geometrical interest, and this in its turn to finite geometries – projective planes and higher spaces over Galois fields. This brings us to the block of papers **[34]**–**[41]**, **[43]**–**[52]**, the body of work for which the author will doubtless be mainly remembered. Again we find characteristic touches, in which the results of other experts like L. E. Dickson and J. S. Frame are kindly acknowledged, then recast in more appropriate geometrical settings.

To take an example, over GF(3) a line contains 4 points, a plane has 13 and a 3-space S has 40. In S there are two kinds of quadric. The ruled quadric or hyperboloid typified by

$$H : x^2 + y^2 + z^2 + t^2 = 0$$

contains 16 points which can be partitioned in two ways into sets of 4 lines, its two reguli. There is a group of 288 direct projectivities, corresponding to orthogonal matrices of determinant 1, which leave H invariant. This is the first orthogonal group $PO_1(4, 3)$; it has a subgroup of index 2 isomorphic to the direct product of two alternating groups of degree 4 which act as permutation groups on the lines of the reguli. The 24 points not on H are the vertices of 6 tetrahedra and these constitute two associated desmic tetrads. This set-up, involving tetrahedra in multiple perspective, is one of those classical configurations whose ubiquity was a constant source of pleasure to Edge.

In contrast the ellipsoid

$$F : x^2 + y^2 + z^2 - t^2 = 0$$

in S has only 10 points and no lines. Associated with it is an elaborate structure typical of those which he analysed so perceptively. There are now 30 points not on F; they fall into two sets of 15, "positive" or "negative" according as $x^2 + y^2 + z^2 - t^2 = 1$ or -1. A *positive pentahedron* has as faces five planes, no four having a point in common; there are ten vertices all of which are positive points and ten edges each tangent to F. One finds six of these objects and analogously six negative pentahedra. There are 360 direct projectivities which map F to itself and do not interchange positive and negative pentahedra. They contribute the second orthogonal group $PO_2(4, 3)$. Each induces a different permutation of the six positive pentahedra and this establishes the isomorphism of $PO_2(4, 3)$ and A_6. This is in **[34]**. In a sequel **[36]** the Klein representation of the lines of [3] by points of [5] is investigated in meticulous detail over GF(3), yielding a representation of the cubic surface group of order 51840 and other well-known groups; see also [39], [41]. Later work [45] approached the cubic surface group via GF(2) and likewise, in [47], the group of the bitangents (of a non-singular plane quartic). On passing from GF(3) to GF(3^2) the automorphism $x \to x^3$ of the finite field enables Hermitian structures to be introduced. The resulting 10-point line has fascinating harmonic and anharmonic properties. In [37] such considerations serve to illuminate the isomorphism of $LF(2, 3^2)$ and A_6.

Although some very large groups are amenable to this treatment (as evidenced by the title of [49]), the recent discoveries of various sporadic simple groups came a little late for him, and they may not have proved accessible to his technique. However one paper [57] is inspired by work of J. H. Conway. With retirement approaching he returned largely to classical topics though a few groups still received attention [83, 86, 87]. Special curves and surfaces again came under the microscope. It is remarkable that properties of so simple a curve as the intersection of two quadrics in [3] remained to be elucidated but in [60] work of Enriques is corrected and amplified. This concerns chords which lie in the osculating planes at both extremities; there are 24 of these. The same curve features in [73]. The papers of this later period do not, as a whole, lend themselves to ready summary. Once more, though, we meet objects with a rich special structure such as Bring's and Fricke's curves [71, 77, 84] given by beautifully simple equations typified by

$$x+y+z+t+u = x^2+y^2+z^2+t^2+u^2 = x^3+y^3+z^3+t^3+u^3 = 0$$

for the first named, and the author's algebraic skills are displayed to good advantage yet again.

Particular notice should be made of [75], appropriately published by the Royal Irish Academy. Here a mistake by his hero Salmon, perpetuated in *A treatise on the analytic geometry of three dimensions* (Dublin, 1862 and subsequent editions) is identified – does one detect a certain glee? – and corrected. Librarians and readers are urged to amend their copies! The attention of those interested in classical invariant theory should also be drawn to the closing paragraph of [89]. The binary nonic has two independent quartic invariants. The geometry of one of these had been treated in [88] but the interpretation of the other is an open problem to which he returned in conversation even in his very last days. Any one resolving it could well dedicate their efforts to his memory. Finally, look at [92] and [93]. Whilst it is virtually certain that Edge never laid hands on a modern computer he evidently did, perhaps reluctantly, recognize its powers. He was pleased to accept and acknowledge the assistance of a colleague, Darrell Desbrow, in preparing illustrative diagrams. The twentieth century had arrived at last.

To conclude, in reviewing the work one cannot fail to be impressed by the splendid vision and exhaustive detail. It must be cause for regret that he had only one research student, James Hirschfeld. Surely others could have benefited from his erudition and enthusiasm. His geometry was essentially "visual", even when higher dimensions were involved. One feels that he is *seeing* the points, lines and planes in their wonderful configurations and wants the reader to do the same. It is sad, too, that, perhaps being perceived as old-fashioned, his labours did not receive greater and earlier recognition. There must be much that can be distilled from his writings in years to come.

PUBLICATIONS

Book

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DAVID MONK
16 CADOGAN ROAD
EDINBURGH
EH16 6LY