Zeeman, Sir (Erik) Christopher
(1925–2016)
Ian Stewart

Zeeman, Sir (Erik) Christopher (1925–2016), mathematician, was born on 4 February 1925 in Kyoto, Japan, the son of Christian Zeeman, formerly Zeemann (1892–1929), a Danish fish merchant, and his English wife, Christine, *née* Bushell (1889–1968), daughter of William Bushell, merchant. His parents had married in London in December 1919 and he had one sister, Catherine (*b.* 1921). After their father's death the children were brought back to England by their mother, who then worked as a governess. Zeeman was educated at Christ's Hospital, Horsham. In 1943 he joined the RAF, serving as a flying officer until 1947. Posted to the Pacific in the latter stages of the Second World War, he was spared being deployed on bombing missions against the country of his birth only by the dropping of the atomic bombs.

On demobilization Zeeman went to Christ's College, Cambridge, where he read mathematics, staying on to take a PhD under Shaun Wylie. In 1953 he was elected a fellow of Gonville and Caius College, Cambridge; he was a Commonwealth fellow in 1954 and became a Cambridge university lecturer in 1955. Meanwhile, on 12 August 1950 he had married Elizabeth Jones (1925–1980), a scholar of medieval English, and daughter of Evan Arthur Jones, local government official. They had a daughter, Nicolette (*b.* 1956), but were divorced in 1959 (Elizabeth went on to marry the psychologist David Salter) and on 30 January 1960 he married Rosemary Gomme, *née* Gledhill (1931–2019), jeweller and enameller, daughter of Harold Samuels Gledhill, draughtsman, and former wife of Austin Harvey (Andor) Gomme, architectural historian. They had five children: Tristan (*b.* 1960), Mary Lou (*b.* 1961), Crispin (*b.* 1965), Francesca (*b.* 1967), and Samuel (Sam) (*b.* 1970).

Zeeman's PhD thesis, *'Dihomology'*, was on algebraic topology, and it introduced an important technique, the 'Zeeman spectral sequence'. Robert MacPherson and Mark Goresky developed his ideas to create intersection homology, which led to proofs of the Kazhdan–Lusztig conjectures in representation theory and the Riemann–Hilbert correspondence for complex differential equations. Topology is about properties of shapes that are unchanged by continuous deformations, such as being connected or disconnected, knotted or unknotted. In a 1967 radio broadcast Zeeman described it as 'flexible geometry'.

In 1960 Zeeman proved in a half-page paper that every sphere in five-dimensional space can be unknotted, answering a long-standing question. In 1961 he proved the Poincaré Conjecture for spaces of dimension five or higher, a theorem proved independently by John Stallings. This conjecture, proposed in 1904 by the great French mathematician Henri Poincaré, was originally stated for the three-dimensional sphere and posed as a question. Its more general form characterizes high-dimensional analogues of the sphere in terms of simple topological properties. Progress had to wait until the 1960s, and the original version resisted attack until 2003, when it was proved by Grigori Perelman.

In 1962–3 Zeeman spent some time at one of the world's foremost research centres for mathematics and theoretical physics, the Institut des Hautes Études Scientifiques (IHES) at Bures-sur-Yvette, near Paris, France. His research started to diversify; in 1964 he showed that special relativity can be based solely on the notion of causality, and in 1965–6 he applied tolerance spaces to the brain.

A major career move occurred in 1964, when the vice-chancellor-elect of the new University of Warwick (officially founded in 1965), Jack Butterworth, offered Zeeman a chair. His task would be to set up, from scratch, a top-quality mathematics department. Zeeman said:

'At first I said "no", then changed my mind after a sleepless night …. I had always thought that Cambridge was the centre of things, but I grew as a mathematician at Warwick'

(Arnot, 21).

Fifty years later there were many international centres specializing in mathematical research, but in the 1960s the main ones were the Mathematisches Forschungsinstitut Oberwolfach in Germany, the Instituto Nacional de Matemática Pura e Aplicada in Rio de Janeiro, and the IHES. The UK's

Science Research Council had expressed interest in funding a British centre along similar lines, and Zeeman seized the opportunity to found one at Warwick. So as well as an academic department, he created the Mathematics Research Centre (MRC). Together these would form the Mathematics Institute. Initially, Zeeman ran both. He decided that the best way to create a flourishing research environment was to start with closely knit specialist groups. Breadth could come later, but initially depth was the key to a successful future. So he began by making appointments in what he referred to as the 'three pillars of modern mathematics': topology, algebra, and analysis. Initially he invited several key figures to join him. According to a persistent legend, they all declined, so he wrote to each of them saying, 'that's a pity, the others have all accepted'. He never denied this. He was seldom devious, but he was adaptable if the occasion demanded it.

Traditionally, British mathematics had long been divided into 'pure' and 'applied', but Zeeman always saw it as a continuous spectrum between these extremes, and he liked to inhabit the territory in the middle. In Warwick's early days, applied mathematics was mainly the concern of the departments that applied it, such as physics and engineering, so most staff in the mathematics department were pure mathematicians. Over the years, the university changed how applied mathematics was organised, and the mathematics department hired applied mathematicians too.

The Mathematics Research Centre started by hosting a series of annual symposia: year-long special programmes on cutting-edge topics that attracted hundreds of the world's top mathematicians. This gave it international prominence very early on, and 2000 mathematicians from around the world visited in its first ten years. The Mathematics Institute began as a house on Kenilworth Road, Coventry, but quickly moved to a larger house, where Stoneleigh Road intersected Kenilworth Road and became Gibbet Hill Road. The department also had extra offices for staff and postgraduates in what had been the university library.

Zeeman took a special interest in mathematical biology—a subject which, in the 1960s, hardly existed. With the great advances being made in molecular biology, in particular Francis Crick and James Watson's elucidation of the structure of DNA, most biologists were unconvinced by any suggestion that mathematics could help them understand the living world—apart from statistics for analysing experimental data, Bragg's law in X-ray diffraction, and the Hodgkin-Huxley nerve impulse equations.

Zeeman once said that mathematicians divided into two broad camps: those who remained in one subject area and learned any new techniques that arose, and those that specialized in particular methods and followed them wherever they could be applied. He was in the second camp, and his technique was geometry: not in the formal sense of Euclid, but in the free-flowing modern sense of thinking visually about mathematical problems. Pursuing topology where it led was soon to have a major effect on Zeeman's research. The change probably began when he spent 1966–7 as a visiting professor at the University of California, Berkeley, where Stephen Smale was in the process of creating the modern theory of nonlinear dynamical systems. In 1968–9 this area was the focus of Warwick's annual symposium. Smale visited, and so did the French mathematician René Thom. The following year, Zeeman spent a sabbatical with Thom at IHES. Thom was developing what he called a 'theory of models', a top-down approach to mathematical models of reality. Thom argued that this was especially important in biology, where exact equations were unknown, so deductions based on any specific choice were questionable. This idea led him to the 'catastrophes élémentaires', a topological classification of sudden changes. Zeeman spotted an opportunity to use his beloved geometry to model problems in the real world. He gave the world's first lecture course on the topic, and interacted with scientists from many areas—biology, physics, economics, statistics, even sociology. He said that

'Amongst my applications of catastrophe theory I particularly liked buckling, capsizing, embryology, evolution, psychology, anorexia, animal behaviour, ideologies, committee behaviour, economics, and drama'

(O'Connor and Robertson, MacTutor History of Mathematics).

He collected some of his research in his book *Catastrophe Theory: Selected Papers, 1972–77* (1977). The subject attracted what was then an unusual level of media attention, leading some to denounce 'catastrophe theory' as hype. However, the theory, renamed singularity theory as it grew in generality, became an important technique in many applied areas. In a paper in *Nature* in 2013 one of his proposals, a 'clock and wavefront' model of a key stage in the development of a vertebrate,

was shown to be correct.

Zeeman had a practical turn of mind. He made a gadget out of wood and a roll of lining paper to display the speakers, times, and titles of the many seminars that were taking place in the Department. In 2019 it was hanging on the wall in the common room, as a historical artefact, but by then its role had been taken over by a computer-controlled display. To illustrate the sudden jumps that are characteristic of elementary catastrophes, he invented a 'catastrophe machine' involving a circle of card pinned to a piece of wood, to which are attached two elastic bands. This became famous. It is said that when he took it with him to give lectures in the USA, and told Immigration officials the name of the device, they cleared the room and had him arrested.

Zeeman was a workaholic. He involved himself in mathematics at all levels, from primary school teaching to the Royal Society. He was an inspiring lecturer and public speaker, with a knack for making complicated ideas seem simple. He was very active in public engagement, at a time when this was unusual for an academic. In 1967 he appeared on the radio (BBC Third Programme) talking on *'Topology in the Scientist's Toolkit'*. His greatest media achievement was to deliver the 1978 Royal Institution Christmas lectures on BBC television. At Christmas in 1825 Michael Faraday had given a short series of popular lectures, aimed at young people, with lots of demonstrations, and the series continued thereafter. Mathematics was almost invisible early on, although in 1936 Geoffrey Ingram Taylor gave lectures on the dynamics of ships. Remarkably, the BBC televised one lecture only two weeks after the start of regular transmissions. As it happens, Zeeman discovered that ship stability is a beautiful application of catastrophe theory. He was the first pure mathematician to give the Christmas lectures, on topics including knots, boomerangs, gyroscopes, perspective drawing, music, and catastrophe theory.

Zeeman was elected a fellow of the Royal Society in 1975. He received the senior Whitehead prize of the London Mathematical Society (LMS), the UK's major pure mathematics professional body, in 1982, and became the society's president from 1986 to 1988. During that period he gave the first series of Forder lectures in New Zealand, run jointly by the LMS and the New Zealand Mathematical Society. In 1988 he was awarded the Royal Society's Michael Faraday prize for promoting the public understanding of science. From 1988 to 1994 he was professor of geometry at Gresham College, giving twelve free public lectures a year on mathematical topics. He was an able administrator, and chaired the mathematics committee of the Science and Engineering Research Council, creating its Nonlinear System Initiative. He put his experiences founding Warwick's MRC to good use, becoming chair of the first scientific committee of the new Isaac Newton Institute at Cambridge, overseeing its construction and its scientific programme.

In 1988 Zeeman left Warwick University to become principal of Hertford College, Oxford, largely because at that time there was a mandatory retirement age at Warwick of sixty-seven, whereas at Oxford it was seventy. In 1991 he was knighted for 'mathematical excellence and service to British mathematics and mathematics education'. He won the David Crighton medal of the LMS and the Institute of Mathematics and Its Applications in 2006, 'for services to mathematics and the mathematics community'.

Zeeman was a visiting professor at various institutes and universities including the Institut des Hautes Études Scientifiques, Paris; the Instituto Nacional de Matemática Pura e Aplicada, Rio; the Royal Institution; and the universities of Princeton, California, Florida, and Pisa. He received honorary degrees from Strasbourg, Hull, York, Leeds, Durham, Hartford, and Warwick universities, Claremont Graduate University, and the Open University. The Institute of Mathematics and Its Applications and the London Mathematical Society jointly set up the Zeeman medal in his honour, for activities in public awareness of mathematics. In 2015 large gathering of family, friends, and colleagues celebrated his ninetieth birthday at Hertford College.

Zeeman was good-looking, with a neatly trimmed beard, and almost tangible charisma. His normal manner was charming, but he was a fearsome opponent in academic politics. His usual technique was to anticipate objections and compile evidence beforehand to shoot them down. If he did not get what he wanted, he would wait for a time, and then ask again, having prepared an even stronger case. His public lectures left his audience enthused and excited, and he was adept at slipping past technical difficulties. His non-mathematical interests included fine wines and art. He was especially keen on the Renaissance period, both for its paintings and its sculpture, but his tastes were quite broad, including ancient Egyptian sculptures, some modern art, and Makonde sculptures from

Tanzania and Mozambique.

Zeeman's greatest tangible memorial was the Warwick Mathematics Institute. Under his leadership as founding professor and director of the Mathematics Research Centre, and with the enthusiastic assistance of his staff, this fledgling operation grew rapidly into a major world research centre. By its fiftieth anniversary Warwick was one of the UK's top six mathematics departments, and its degree programme was assessed as number thirteen in the world. The Mathematics Institute moved to the central campus into much larger premises, named the Zeeman Building. This was rapidly extended, and in 2019 an adjoining Mathematical Sciences Building was built, also linked to the statistics and computer science departments—a development fully consistent with Zeeman's aims, from the very start.

Zeeman lived latterly at 23 High Street, Woodstock, Oxfordshire. He died there on 13 February 2016 of pneumonia and heart disease. His second wife, Rosemary, died in March 2019, at home in Wardington, Oxfordshire. He was survived by his six children. Three of them followed him into academia: Nicolette as a scholar of medieval literature, Mary Lou as a mathematician (and collaborator with her father in three papers), and Sam as a biologist.

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A. Barrington Brown, photograph, with Elizabeth Zeeman, 1954, NPG

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P. D. Edwards, oils, 1993, Hertford College, Oxford

obituary photographs

External resources