Thomas Kibble

(1932–2016)

Theoretical physicist and Higgs-boson pioneer.

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Tom Kibble contributed to our deepest understanding of the fabric and forces of the Universe. He is best known for his work on the phenomenon called spontaneous symmetry breaking — a cornerstone of the standard model of particle physics. His work led to the concept of a new elementary particle now known as the Higgs boson, which was experimentally observed in 2012. Kibble was also a pioneer in applying ideas from both high-energy physics and condensed-matter physics to the study of the early Universe.

Thomas Walter Bannerman Kibble, who died on 2 June, was born in 1932 in Madras (now Chennai), India. His father was a professor of mathematics. He was sent to Edinburgh in 1944 to complete his secondary education at Melville College. Between 1951 and 1958, he pursued a degree in physics and a PhD in mathematical physics at the University of Edinburgh. During the final year of his PhD he married Anne Allan, with whom he had three children. They were happily married until her death in 2005.

In 1959, Kibble joined the theoretical-physics group at Imperial College London, starting an association with the institution that would last for nearly 60 years. It was in the summer of 1964 that, along with US physicists Gerald Guralnik and Carl Richard Hagen, he wrote a seminal paper on symmetry breaking (G. S. Guralnik *et al. Phys. Rev. Lett.* **13,** 585–587; 1964).

Symmetry and the breaking of symmetry are deep principles that arise in many different physical contexts. In a lump of iron, for example, the interactions of the atoms respect a perfect symmetry between different directions in space. However, when the iron is cooled to below 770 °C it generates a magnetic field that points in a specific direction, selected spontaneously, and the rotational symmetry is said to be spontaneously broken.

During the early 1960s, initial attempts to incorporate spontaneous symmetry breaking into particle physics showed that certain kinds of massless particle would necessarily be predicted. However, Kibble, Guralnik and Hagen studied spontaneous symmetry breaking in the context of a realization of symmetry called gauge symmetry. In so doing, they reached the striking conclusion that, instead, certain kinds of elementary particles called vector bosons would actually acquire mass.

This beautiful mass-generating mechanism was independently described slightly earlier in 1964, first in a paper by Belgian physicists Robert Brout and François Englert, and then in a second paper by Peter Higgs, who also explicitly noted that the mechanism gives rise to another massive particle, now known as the Higgs boson.

The significance of these elegant ideas was not immediately recognized. The electromagnetic force is mediated by the photon, a vector boson, but photons are massless. By contrast, the early theory of the weak nuclear force, another of the four fundamental forces of nature, did require massive vector bosons, now called the W and Z bosons. In a key single-author 1967 paper, Kibble showed how the symmetry-breaking mechanism can be generalized, and showed, crucially, how it can leave a vector boson, such as the photon, massless while giving masses to others (T. W. B. Kibble *Phys. Rev.* **155,** 1554; 1967).

These insights became central components in the unification of the electromagnetic and weak nuclear forces into the electroweak theory. (Building on earlier work of Sheldon Glashow, this was formulated in 1967 by Abdus Salam and Steven Weinberg.) In 2010, Kibble shared the American Physical Society's J. J. Sakurai Prize for Theoretical Particle Physics with the five other scientists credited with discovering the spontaneous symmetry-breaking mechanism.

In 2013, Englert and Higgs were awarded the Nobel Prize for Physics. Many people in the theoretical-physics community, including Higgs, hoped that Kibble would be chosen to share this award. Kibble himself, a man of great modesty, never expressed any disappointment.

In 1976, Kibble laid the foundations for a second key phase of his scientific career. Drawing on ideas from both high-energy physics and condensed-matter physics he realized that phase transitions in the early Universe could leave observable cosmological signatures. He showed that for certain conjectured theories of high-energy physics, the mechanism of spontaneous symmetry breaking predicts novel structures, including one-dimensional concentrations of energy that stretch across the cosmos, which he called cosmic strings.

Kibble analysed how cosmic strings evolve after the phase transition and suggested that they could have a significant impact on the history of the early Universe. Measurements of the cosmic microwave background, the relic radiation from the Big Bang, now indicate that cosmic strings are not the dominant mechanism for creating the large-scale structure of galaxies. Nevertheless, the detection of cosmic strings in future experiments would still provide momentous new insights into the fundamental forces.

Among his many honours, Tom was made a Commander of the British Empire in 1998 and was knighted in 2014. He was especially proud of being the first recipient of the *Nature*/NESTA lifetime achievement award for mentoring in 2005.

Tom was quiet and gently spoken, but he had an influential leadership role in UK academia. As head of the physics department at Imperial College from 1983 to 1991, he skilfully steered it through a difficult period of low funding for science in the United Kingdom.

Tom was also an active campaigner. He joined the British Society for Social Responsibility in Science soon after its formation in 1969, and for three years was chair of the organization's national committee. He was also chair of Scientists Against Nuclear Arms from 1985 to 1991.

Tom changed our understanding of the Universe at the deepest level. He was a man of great integrity and was regarded with much admiration and affection by his colleagues and students. ■

Jerome Gauntlett *is head of theoretical physics at Imperial College London.*
email: j.gauntlett@imperial.ac.uk