OBITUARIES

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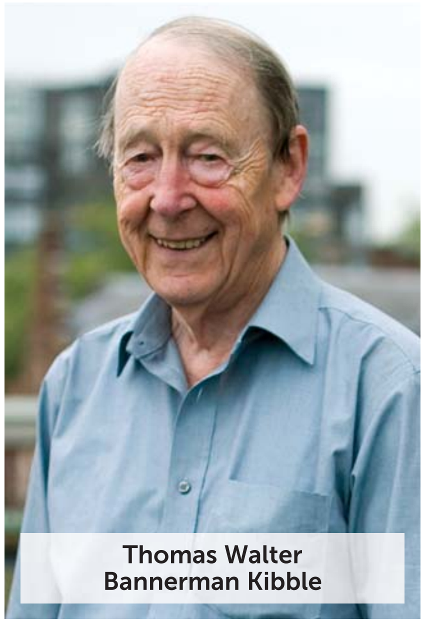
Thomas Walter Bannerman Kibble



Thomas Walter Bannerman Kibble

Thomas Walter Bannerman Kibble, who died in London on 2 June 2016, is best known for his deep insights into the nature of symmetry breaking and its consequences. His research combined ideas from high-energy and condensed-matter physics and had a profound effect on both. He was admired as much for his kindness and humanity as for his contribution to physics.

Tom was born in Madras, India, on 23 December 1932. His father was a professor of mathematics. Tom obtained his MA in mathematics and natural philosophy in 1955, his BSc in physics in 1956, and his PhD in mathematical physics, under John Polkinghorne, in 1958, all from the University of Edinburgh. A year later he joined the physics faculty of Imperial College London; he was associated with Imperial for the rest of his life.

Tom was widely revered throughout the UK and the international physics community for his profound, quick mind; his mastery of modern physics; his deep humility; and his willingness to help others. His openness to new ideas drew many to seek his opinion. UK theoretical cosmology workshops, for example, started out as small informal gatherings in his office but grew into major meetings that would attract more than a hundred attendees. Tom was head of Imperial's physics department from 1983 to 1991 during difficult times, and left it in a healthy condition. His sense of morality and social responsibility led him to join and eventually chair Scientists Against Nuclear Arms, which was a significant force in mobilizing scientists in the UK to speak out against nuclear weapons.

Among Tom's seminal physics ideas, two stand out. A 1964 paper he coauthored with Gerald Guralnik and Carl Hagen described a spontaneous symmetry-breaking mechanism that in theories with local gauge symmetries endows elementary excitations with mass. That same mechanism was independently and simultaneously proposed by Robert Brout and François Englert and by Peter Higgs, who also pointed out that it would lead to what is now known as the Higgs boson. In 1967 Tom generalized the symmetry-breaking mechanism to explain why some vector bosons become massive while leaving the photon massless. The results were central to the unification of electromagnetic and weak interactions. Many physicists thought the 1967 paper was so influential that Tom should have been included in the award of the 2013 Nobel Prize in Physics. Although he missed out, he never showed any disappointment; such was his modesty.

Understanding the consequences of symmetry breaking in cosmological phase transitions was the second of Tom's deep insights. Phase transitions are traditionally studied in equilibrium. Equilibrium phases have long-range order—the system symmetry is everywhere broken the same way (for example, the same lattice orientation in the whole crystal or the same phase of the quantum wavefunction in the whole superfluid). In the nascent universe that cools after the Big Bang, symmetry-breaking phase transitions are expected.

Tom realized that rapid post–Big Bang cooling leaves no time for the universe to build a uniform consensus about how to break symmetry: A new, local phase is independently established in domains of the size of the causal horizon at the transition instant. In the nascent universe, that horizon is a tiny fraction of our present universe.

A mosaic of different broken-symmetry choices must therefore appear when the transition is rapid. As Tom pointed out in a seminal 1976 paper, such disparate choices lead to the formation of topological defects—relics of the pretransition phase. In superfluids, they are the familiar vortex lines. Their analogue, cosmic strings, is the hypothetical early-universe example.

Causality sets the lower limit on the density of topological defects in the early universe. Tom speculated that structures we observe, such as galaxies, may be seeded by cosmic strings. Moreover, topological defects create magnetic monopoles in all viable particle-physics models, yet we do not see them. That tension, which grew out of Tom's work, led to the development of inflationary cosmology. Tom was truly a trailblazer of those very ambitious and far-reaching scenarios for the universe.

The consequences of Tom's work are profound and dramatic. Their exploration remains one of the main subjects of cosmology, even though massive cosmic strings that could have resulted in galaxy formation are ruled out by measurements of the microwave background.

Symmetry breakings can occur at any temperature, from somewhat below the Planck temperature of ~10^{38} K post–Big Bang to ~10^{-9} K for gaseous Bose–Einstein condensates. Phase transitions are famously universal—their near-critical behavior is independent of microphysical details. Thus, although relativistic causality (light's finite speed) isn't relevant for experimentally accessible transitions, Tom's insight that broken symmetry

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must be chosen locally is crucial; his realization that rapid transitions lead to defects also applies to condensed-matter physics. One can replace relativistic causality with reasoning based on scaling of a system's "reflexes" that deteriorate near the critical point ("critical slowing down") or, equivalently, rely on the existence of a sonic horizon (an analogue of the causal horizon) to predict the size of the domains that break symmetry and, hence, estimate the density of defects. (See Tom's feature article, PHYSICS TODAY, September 2007, page 47.) The past few years have seen increasingly precise quantitative confirmations of Tom's ideas in systems that range from solid state, such as multiferroics, to Bose–Einstein condensates.

Tom's legacy is evident in the scope of his work—from the origin of fundamental forces via cosmology and particle physics to condensed matter. His contributions were recognized by numerous prizes, including the first *Nature*/NESTA lifetime achievement award for mentoring, in 2005; the American Physical Society's 2010 J. J. Sakurai Prize (shared with the other discoverers of the Higgs boson); the Royal Medal of the Royal Society in 2012; a knighthood, bestowed on him in 2014; and, posthumously, the Isaac Newton Medal of the Institute of Physics.

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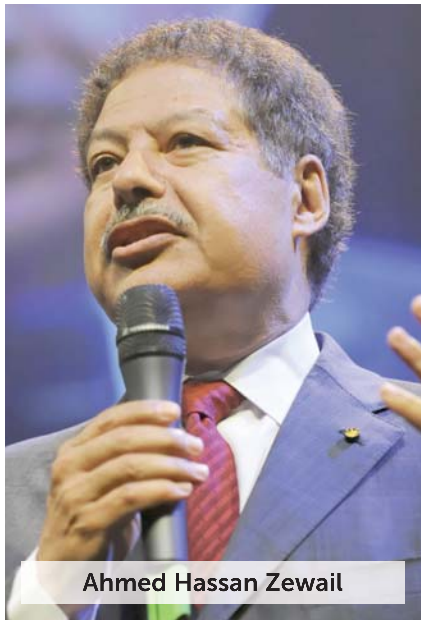
Ahmed Hassan Zewail

On a summer day in 2008, during one of my stays at Caltech, I watched how Ahmed Hassan Zewail, the sole recipient of the 1999 Nobel Prize in Chemistry, welcomed an enthusiastic physics master's student from New York who wanted to meet him. I was amazed to witness Ahmed explain his research to the young man; Ahmed had the excitement, fascination, and joy of a PhD student getting his first results. That attitude embodies Ahmed's personality: a man who despite reaching the acme of prestige and international recognition kept a passion and rigor for science and continued to be tremendously generous and display an intelligence of the heart in his relations with others.



Ahmed Hassan Zewail

Ahmed was born on 26 February 1946 in Damanhur, Egypt, and died on 2 August 2016 in Pasadena, California, from multiple myeloma. He obtained his bachelor's and master's degrees in chemistry from Alexandria University in 1967 and 1969, respectively. He then attended the University of Pennsylvania for his PhD; his thesis, on optical and magnetic resonance spectra in molecular crystals, was supervised by Robin Hochstrasser. After obtaining his doctorate in 1974, Ahmed spent two years as a postdoc in Charles Harris's group at the University of California, Berkeley, where he used, for the first time, the recently developed picosecond lasers. That experience proved crucial for his future career; in 1976 he became an assistant professor at Caltech and started picosecond laser studies of molecular systems.

From a series of experiments that he called "mind opening," Ahmed developed new concepts about molecular coherence. Those were the stepping-stones to the birth of a new field of research: femtochemistry. When the first femtosecond lasers appeared in the mid 1980s, Ahmed was well aware of the powerful tool they presented. He quickly achieved a series of breakthroughs by visualizing in real time the nuclear motion of simple molecular systems.

Ahmed then studied atomic edifices of ever-greater complexity—large molecules, clusters, proteins, and solutions.