nia, Jones became a professor of mathematics at Berkeley.

After graduating from Brandeis University with a bachelor's degree in history, Witten entered graduate school in physics at Princeton University. He received his PhD in 1976 and, after holding two brief fellowships, became a physics professor at Princeton in 1980. In 1987 Witten became a professor of natural sciences at the Institute for Advanced Study.

OBITUARIES

William M. Fairbank

Bill Fairbank, 72, died on 30 September 1989 of a massive heart attack while jogging near the Stanford University campus. He was an avid runner throughout his life, and in recent years competed in the International Masters Meets for seniors. His great interest in sports was exceeded only by his passion for physics and for his family.

He was a giant among experimental physicists, recognized for his brilliant experiments with liquid helium and superconductors and for his ingenious use of low-temperature techniques to explore the frontiers of physics in elementary particles, gravitational waves and general relativity.

Born in Minneapolis, Minnesota, on 24 February 1917, Fairbank—along with his future wife, Jane Davenport, and his younger brother, Henry, who is also a distinguished low-temperature physicist—graduated from Whitman College, with AB degrees in chemistry (1939) and physics (1940). After 18 months as graduate students at the University of Washington, he and Jane became members of the scientific staff at the MIT Radiation Laboratory, where they worked on overwater tests of radar. After the war Fairbank reentered graduate school at Yale and earned his PhD working with C. T. Lane in one of the first low-temperature groups in the US. Fairbank's highly original dissertation was on the surface resistance of superconducting tin at microwave frequencies—research that contributed vitally to the superconducting particle accelerator built at Stanford in the 1960s and subsequently to the Continuous Electron Beam Accelerator Facility, currently under construction at Newport News, Virginia.

William M. Fairbank

From 1947 to 1952 Fairbank was an assistant professor at Amherst College. He then moved to Duke University where, during the next seven years, he established his reputation as an extraordinarily bold and profound physicist. In 1954, with his students and colleagues, he performed the first measurements demonstrating the Fermi–Dirac degeneracy of liquid ^{3}He, using the then new technique of nuclear magnetic resonance at 0.25 K, a temperature that was, at the time, by no means easy to obtain. Also using nmr techniques he and his group discovered an unexpected phase transition of ^{3}He–^{4}He solutions into dilute and concentrated phases at 0.8 K. In 1957, with Michael Buckingham and Fred Kellers, Fairbank measured the specific heat of liquid ^{4}He near its superfluid transition temperature to within 1 microkelvin—three orders of magnitude better than had been deemed possible. The three established that the specific heat has extended logarithmic divergences on both sides of the phase transition and a discontinuity at the transition temperature. This work drove future theoretical understanding of second-order phase transitions.

Fairbank was profoundly influenced by his association at Duke with the famous theoretician Fritz London—particularly by London's conception of both superconductivity and the superfluid state of liquid helium as macroscopic quantum phenomena. After Fairbank joined the faculty at Stanford University in 1959, several of the experiments he undertook were designed to test predictions made by London.

One of Fairbank's most important experiments was his first at Stanford. In 1961, with his graduate student Bascom Deaver Jr, he observed fluxoid quantization in superconductors by measuring the trapped magnetic flux in superconducting cylinders and finding that it occurs in integral multiples of $h/2e$. This extraordinary experiment demonstrated both the macroscopic quantum nature of superconductivity and the pairing of electrons in the superconducting state. Fairbank's later experiments with rotating superconductors included the first observation, in 1963, of the London moment, a magnetic moment that arises from the macroscopic quantum nature of the superconducting state and is proportional to the angular velocity of the superconductor. After that experiment, Fairbank and his students and associates detected the quantized angular-momentum states of rotating superfluid ^{4}He (1967) and observed nuclear antiferromagnetism in solid ^{3}He (1969).

In a second, quite different, phase of his career, Fairbank initiated, with various colleagues, a series of large-scale, long-term experiments that have in common the application of low-temperature techniques to explore crucial questions in other areas of physics. One such project has been the construction of the superconducting electron accelerator based on niobium rf cavities. This undertaking necessitated the development of cavities with Qs as high as 10^{11}, superfluid helium technology on an unprecedented scale and new principles of accelerator design. Work on the accelerator began in 1961 under the direction of Alan Schwettman, who continues to direct its use today. The accelerator's unique properties were essential to its use for the first demonstration of the free-electron laser by John Madey, Todd Smith and Schwettman.

Stimulated by the ideas of the distinguished Stanford theorist Leonard Schiff, who in 1959 conceived two new tests of Einstein's general relativity based on the precession of gyroscopes in Earth orbit, Fairbank and Robert Cannon initated experiments using an exquisitely precise cryogenic gyroscope. It turned out that the discovery of the London moment provided an elegant solution of how to sense the angular position of their perfectly spherical gyroscope. These experiments evolved into a large-scale NASA program now led by Francis Everitt, who began work on it with Fairbank in 1962 together with Bradford Parkinson and John Turneaure. A test flight is scheduled for 1994, and a science mission launch is targeted for December 1997.

In 1969 with William Hamilton—then an assistant professor at Stanford and now a professor at Louisiana State University—Fairbank initiated a third large-scale project, a search for gravitational radiation, following the method originated by Joseph Weber. As Weber had done, Fairbank used a massive aluminum bar as an antenna, but Fairbank's bar, unlike Weber's, was cooled to 2 K and equipped with superconducting detectors to sense its vibration. The gravitational-wave search started by Fairbank has grown into an active collaboration including Stanford, LSU and the University of Rome. Leading the work at Stanford, Peter Michelson is currently operating a bar that will be cooled to 10 mK, making it sensitive enough to detect the gravitational collapse of a star anywhere in the Milky Way or other nearby galaxies.

Fairbank's most controversial project was his search for free fractional charge in matter. In this experiment, a superconducting niobium microsphere is levitated in a magnetic field between capacitor plates, and the sphere's charge is measured by observing its motion in an oscillating electric field. Reports in 1977, 1981 and 1986 on the results of this experiment all indicate strong statistical evidence for charges with magnitude $\frac{1}{3}e$. The apparatus and technique were continually improved over the years. On the night before his death Bill and his students were taking new data.

For Fairbank's 65th birthday, his students and colleagues organized a three-day conference in his honor, which was attended by some 200 people. Fifty-six papers written by participants in this meeting were woven into a remarkably coherent book, *Near Zero: New Frontiers of Physics* (J. D. Fairbank, B. S. Deaver, C. W. F. Everitt, P. F. Michelson, eds., Freeman, New York, 1988), which, in the words of a reviewer, reveals the "astonishing scope and breadth" of Bill's contributions.

Bill has had an enormous impact on physics and physicists. The excitement and delight he found in physics infected the many students and colleagues who worked with him. We will all miss his incredible enthusiasm, integrity and intuition, and most of all, his friendship.

BLAS CABRERA
C. W. F. EVERITT
Stanford University
Palo Alto, California
BASCOM S. DEAVER JR
University of Virginia
Charlottesville, Virginia

Thomas H. Johnson

Thomas H. Johnson died on 26 June 1990 at the Walter Reed Army Medical Center in Washington, DC, after a year-long battle with cancer. He was 46 years old and had recently retired