

WE HEAR THAT

## WITTEN AND JONES RECEIVE FIELDS MEDALS FOR PHYSICS-RELATED WORK

The winners of the 1990 Fields Medals in mathematics include Vaughan Jones, a mathematics professor at the University of California, Berkeley, and Edward Witten, a professor in the school of natural sciences at the Institute for Advanced Study in Princeton, New Jersey. Jones's work on knot theory has proven to be a powerful tool in statistical mechanics and quantum physics, and much of Witten's research is at the frontier between mathematics and physics.

Jones, Witten and the other two winners—Shigefumi Mori of Kyoto University and Vladimir Gershonovich Drinfeld of the Institute for Low-Temperature Physics and Engineering in Kharkov, USSR—received their medals at the International Congress of Mathematicians held in August in Kyoto, Japan.

The Fields Medals, which are given every four years to mathematicians under the age of 40, are regarded by many as the mathematics equivalents of the Nobel Prizes. They carry a \$15 000 (Canadian) monetary award.

Jones started his mathematics career studying von Neumann algebras, which are based on the well-known algebra used in quantum mechanics

to manipulate operators such as energy or momentum. In 1984, while proving a result about subfactors (von Neumann algebras analogous to the subsystems of a physical system), Jones found that he had constructed a representation of the group of all possible braids on  $n$  strings. Because any knot can be made from one of these braids, Jones suspected a link between the von Neumann algebras and knot theory. Using his formulation of representing each braid as an element in some von Neumann algebra, Jones soon showed that the trace function evaluated for any braid depends only on the knot corresponding to that braid. This result enabled him to construct the "Jones polynomial," an expression that characterizes any non-self-intersecting closed curve (knot), and that is invariant under any stretches or twists that do not break the curve.

Jones and others went on to discover deep links between the Jones polynomials and structures that occur in mathematical physics, for example, the Ising model and other integrable models of statistical mechanics. These links and other considerations led theorists to suspect a connection between the Jones polynomials and quantum field theory. In 1988 Witten found such a connection by interpreting the Jones polynomials in terms of a three-dimensional Yang-Mills gauge theory with an unusual Lagrangian. It was the first non-abelian gauge theory of dimension higher than two whose Lagrangian was exactly soluble. And the expectation values of quark trajectories (or Wilson loops)—which in the usual four-dimensional theory of strong interactions can be calculated only by using powerful approximation techniques—could be found analytically in Witten's model and turned out to be none other than the Jones polynomials.

Witten has been one of the world's leaders in high-energy theory and is a major proponent of superstring

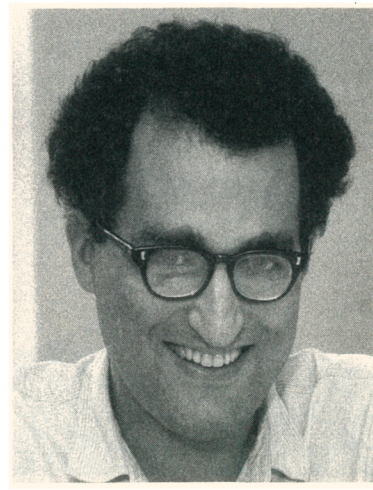
theory, an attempt to integrate the strong, electroweak and gravitational forces by considering elementary particles as resonances of string-like structures in 10 dimensions. Much of Witten's work, including that on the Jones polynomials, is based on Feynman path integrals. For example, he devised the interpretation of supersymmetric quantum theory as the Hodge-de Rham theory in differential geometry, and he has arrived at the only physical interpretation of a mathematical theory called elliptic cohomology by viewing it in terms of two-dimensional supersymmetric field theory. Witten has also found a much simpler alternative to Shoen and Yau's proof of the so-called positive mass conjecture, the theorem that energy must be a positive quantity in general relativity.

After earning his bachelor's and master's degrees, both in mathematics and physics, from the University of Auckland, New Zealand, Jones went to L'Ecole de Mathematiques in Geneva, where he received his DSc in 1979. In 1985, after holding assistant and associate professorships at the University of California, Los Angeles, and at the University of Pennsylvania

Vaughan Jones



Edward Witten



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.

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  $^3\text{He}$ , 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  $^3\text{He}$ – $^4\text{He}$  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  $^4\text{He}$  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  $^4\text{He}$  (1967) and observed nuclear antiferromagnetism in solid  $^3\text{He}$  (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 initiated 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 We-

William M. Fairbank

