John Clive Ward

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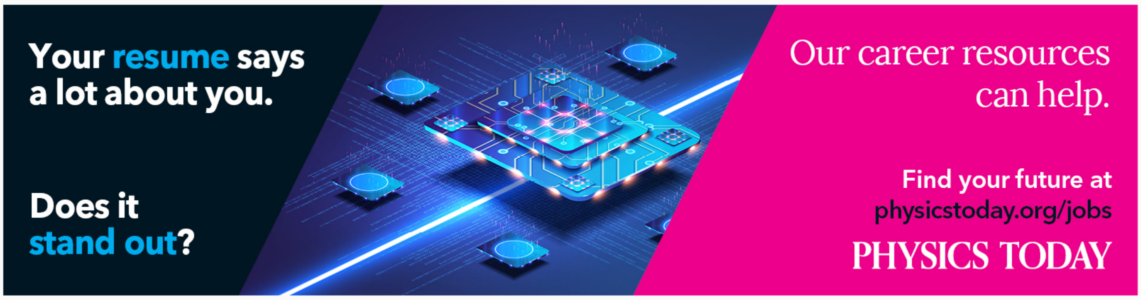

joined the center this past April, was previously a researcher at the Institute of Physics at the Polish Academy of Sciences in Warsaw.

Michael M. Davis in June became the director of SETI projects at the SETI Institute in Mountain View, California. He was previously a senior research associate at Cornell University and a project scientist for the Arecibo Gregorian upgrade at the Arecibo Observatory in Puerto Rico.

After 20 years as editor-in-chief of *Sky & Telescope* magazine, **Leif J. Robinson** retired this month. Succeeding Robinson is **Richard Tresch Fienberg**, who previously served as the president of Sky Publishing Corp, the magazine's parent company, in Cambridge, Massachusetts.

OBITUARIES

John Clive Ward

John Clive Ward, a theoretical and particle physicist, died of a respiratory illness on 6 May on Vancouver Island in British Columbia, Canada.

Ward was born in London on 1 August 1924. He attended the University of Oxford, where he obtained first-class honors degrees in engineering science (1945) and mathematics (1946). He earned his doctorate in theoretical physics at Oxford in 1949.

From 1951 to 1966, Ward accepted appointments at various locations, including the Institute for Advanced Study in Princeton, New Jersey (1951–52, 1955–56, 1960–61); Bell Laboratories (1952–53); University of Adelaide (1953–54); Aldermaston Laboratory in Berkshire, England (1955); University of Maryland, College Park (1956–57); University of Miami (1957–59); Carnegie Institute of Technology (1959–60); Johns Hopkins University (1961–66); and Victoria University of Wellington in New Zealand (1966). From 1967 until his retirement in 1984, Ward was Foundation Professor of Physics at Macquarie University in Sydney, Australia.

The name John Ward first became known for a paper published in *Nature* in 1947 with his research adviser Maurice Pryce. Ward and Pryce calculated, using quantum mechanics, the distribution of the azimuth angle between the planes of polarization of the two gamma rays from positron–electron annihilation, $e^+e^- \to \gamma\gamma$, from rest. In modern terms, the two photons are entangled and, according to "local realism," their polarization planes should become independent long before these gamma rays emerge at macroscopic distances from their origin. This is a typical Einstein-Podolsky-Rosen situation. Already in 1948, observations on the two photons from their source agreed with quantum mechanics, not with "local realism," so it was an important topic.

JOHN CLIVE WARD

Ward always held high standards for himself in both the performance and publication of his work. As he studied Freeman Dyson's papers on the renormalization of quantum electrodynamics, he found gaps in the treatment. The best-known gap concerned Z_2/Z_1, where Z_1 and Z_2 are infinite constants from the theory. Dyson speculated that $Z_2/Z_1 = 1$. Using mathematical operations on Dyson's expressions, Ward obtained an identity that required Z_1 to equal Z_2 for consistency. Students using field theories commonly rely on "Ward's identity," as it is now called. The identity expresses the gauge invariance of electrodynamics. Early in 1951, Ward introduced an original procedure for the renormalization of quantum electrodynamics free from the implications of the overlapping divergence problems in Dyson's procedure. Ward then extended that procedure to systems of nucleons, mesons, and photons. Because of this work, Andrei Sakharov in his memoirs included Ward among the "titans of quantum electrodynamics."

With John Wilks, Ward published two influential papers during 1951–52 on the velocity of second sound in liquid helium near absolute zero. Ward also published several papers on many-particle systems. His work with Mark Kac on the 2D Ising Model was aimed at deriving Lars Onsager's solution by elementary combinatorial arguments. (Onsager's derivation of his solution was unpublished, perhaps indicating that he had not used a deductive approach but, rather, some form of induction. Chen Ning Yang had verified the solution only after elaborate and difficult calculations.) Their success was unexpected by many; it was quite a feat. With Renfrey Potts and Elliot Montroll, Ward used these methods to calculate other properties of the Ising Model. With Quin Luttinger, he calculated the energy of the lowest level of an N-particle system in the form of an infinite series, demonstrated to be convergent. Ward was very capable at finding his way through complicated systems with many degrees of freedom, such as field theory and many-particle theory. His brilliance shone in research on such problems. Most significant were the papers Ward wrote with Abdus Salam. Clearly, Ward's work met Nobel Prize standards: It is central to current research in particle physics and has been accepted as the basic standard model for all particle processes.

In 1955, the British Cabinet decided that Britain must have thermonuclear bombs. Ward was then placed in the Aldermaston (atomic weapons) Laboratory for this purpose, following the recommendations of Winston Churchill's scientific adviser, Lord Cherwell. By the end of 1955, Ward had independently conceived a two-stage device, the radiation from the first (fission) stage being used to compress the light elements of the second stage, leading to a thermonuclear explosion. His design was not understood by his superiors, who were disinclined to accept it, according to an interview with Ward that was published in a newspaper in 1992. Lacking support, Ward left Aldermaston. Three two-stage devices were set off (two weak, then one strong) in the 1957 British tests at Malden Island, and five more (all strong) at Christmas Island in 1958, two years after Ward's departure. Other theoretical physicists had come in to continue the work. These were the only British two-stage devices tested; later, British tests used H-bombs of US design (see *London Review Books,* 22 October 1992, pp. 8–10).

At Macquarie University, Ward played two profoundly important roles with which he was very satisfied later in life. First, with the assistance of physicists such as Claude Curnow, Dick Makinson, Elmer Laisk, and Ron Aitchison, he created a practical physics program designed around *The Feynman Lectures on Physics.* The third-year program included courses in electromagnetism, solid-state, quantum, and experimental physics, in addition to applied mathematics. Ward, who taught at the third-year level, often stated that the two essential courses that made a physicist were electromagnetism and quantum physics. He also believed that, after their third year, students should be capable of performing "serious physics." At Macquarie, Ward continued to work "on the unresolved problems of physics," as he put it; however, his propensity toward self-criticism prevented publication of such work.

His second contribution at Macquarie was his valiant support of the student reform movement that changed the Oxbridge degree structure of Macquarie in the late 1970s. Following a sharp and protracted conflict, Macquarie approved the introduction of science degrees in 1979. Ward regarded his participation in this reform movement as one of his finest achievements.

Ward was an extraordinary man. He was an accomplished pianist and French horn player, and also a wine maker. Once, in response to a comment that he was distant and eccentric, he replied—in his usual low, soft voice—"I think I am perfectly normal." He was honest, frank, and austere. It was his frankness that often brought him into conflict with managers and administrators. He worked on his beloved physics until the end.

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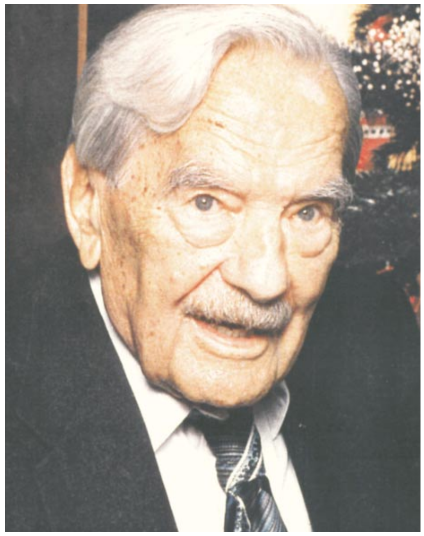
Nicholas Constantine Metropolis



NICHOLAS CONSTANTINE METROPOLIS

Nicholas Constantine Metropolis, one of the pioneers in scientific computing, died in Los Alamos, New Mexico, on 17 October 1999.

Born on 11 June 1915 in Chicago, Metropolis received both his BS (in 1936) and his PhD (in 1941) in chemical physics from the University of Chicago, where his thesis adviser was Robert S. Mulliken. Following graduation, Metropolis had a series of appointments during 1942 and 1943 that greatly shaped his future. First he was a research instructor with James Franck at the University of Chicago. He next became a member of the Manhattan Project under the supervision of Harold C. Urey. He then accepted a staff member position at the University of Chicago's Metallurgical Laboratory under Edward Teller. Teller persuaded Metropolis to become a theoretical physicist, thereby setting him on a path that would affect the world. Urey brought him to Los Alamos at the invitation of J. Robert Oppenheimer in early April 1943.

At Los Alamos during World War II, he endured, with Richard Feynman, the tedium of the slow, clanking, electromechanical devices used for hand calculations needed for weapons design. They actually hung out a shingle for their "repair business." Computing at the Los Alamos Laboratory during the war evolved from hand calculations, to punched-card computations, and then to electronic computing on the Electronic Numerical Integrator and Computer (ENIAC). The first electronic computer, ENIAC was developed at the University of Pennsylvania under the leadership of John Mauchly and Presper Eckert. John von Neumann's association with the ENIAC team, his knowledge of the Los Alamos effort, and his recognition of the profound implications of electronic computing led to his arranging for Stanley Frankel and Metropolis to run the first scientific problem—complex calculations involving the hydrogen bomb design—on the ENIAC in 1945.

The code that was to become the famous Monte Carlo method of calculation originated from a synthesis of insights that Metropolis brought to more general applications in collaboration with Stanislaw Ulam in 1949. A team headed by Metropolis, which included Anthony Turkevich from Chicago, carried out the first actual Monte Carlo calculations on the ENIAC in 1948. Metropolis attributes the germ of this statistical method to Enrico Fermi, who had used such ideas some 15 years earlier. The Monte Carlo method, with its seemingly limitless potential for development to all areas of science and economic activities, continues to find new applications. The Metropolis algorithm, first described in a 1953 paper by Metropolis, Arianna Rosenbluth, Marshall Rosenbluth, Augusta Teller, and Edward Teller, has recently been cited in *Computing in Science and Engineering* as among the top 10 algorithms having the "greatest influence on the development and practice of science and engineering in the 20th century."

Metropolis returned to Chicago at the end the war, but went back to Los Alamos in 1948 to take on the challenge of building a computer that would implement the rapidly developing concepts in digital computation. This effort resulted in the first (of three) Mathematical Numerical Integrator and Computer (MANIAC) at Los Alamos; MANIAC I became operational on 15 March 1952.

From 1953 to 1959 was an intense period of applications of the MANIAC and of the Monte Carlo technique to fundamental problems in physics, chemistry, biology, and mathematics. These efforts culminated in a series of seminal papers with distinguished coauthors in all those fields.

Metropolis returned to Chicago as founding director of the Institute for Computer Research, remaining there from 1957 to 1965. During this period, he was instrumental in developing imaginative new uses for computing. Perhaps his least known, though extremely important, achievement was the invention of online data processing in scientific experimentation. He designed and built—with a soldering iron in his hands—a computer that was coupled to the Navy cyclotron. This computer could receive and analyze data while an experiment was running, allowing the experimenters to modify their experiments during their allotted time. Metropolis also was active in organizing the data