ety of America, received the 2000 National Engineering Award from the American Association of Engineering Societies. Moore was cited "for his multiple contributions in education, industry, and government."

The UK's Royal Astronomical Society honored **Patrick Moore** with a special Millennial Award in recognition of his unique contribution to astronomy. Moore has presented "The Sky at Night" on BBC television every month since 1957.

Paul Alivisatos, a professor of chemistry and of materials science and mineral engineering at the University of California, Berkeley, has been appointed editor of *Nano Letters*, a new journal of the American Chemical Society.

Vigdow Teplitz, a professor of physics at Southern Methodist University, has been named a senior policy analyst with the White House Office of Science and Technology Policy.

Keith Schwab has been named the fourth annual Michelson Postdoctoral Prize Lecturer at Case Western Reserve University. He is currently a senior scientist at the National Security Agency's Laboratory for Physical Sciences at the University of Maryland. The lectureship is awarded annually to a junior scientist in any field of physics.

OBITUARIES

Fredrik Zachariasen

Fredrik Zachariasen, an internationally known theoretical physicist, died suddenly of a heart attack on 9 December 1999 in Pasadena, California.

Fred was born on 14 June 1931 in Chicago. Admitted to an experimental educational program for gifted students at the University of Chicago, he earned his high school diploma in 1948, his BPhil in 1950 and his BS in physics in 1951. Fred's choice of career was no doubt influenced by his father, William H. Zachariasen, who was an internationally known physicist and a dominant figure in the Chicago physics department. Fred received his PhD in physics from Caltech in 1956.

Fred's academic career began with postdoctoral appointments of a year each at MIT, the University of California, Berkeley, and Stanford University. In 1958 he was appointed an assistant professor at Stanford, and in 1960 he accepted a faculty appointment at Caltech. In September 1999 Fred retired from his position as a Caltech physics professor after 39 years of service, and was named professor emeritus.

Fred always required that physics be fun. By that he meant that a problem should be interesting, important, and relevant to experiment and that it have a reasonable chance of being solved. He often constructed simple models that contained the essence of the physics, unencumbered by the complicated mathematical details of the actual problem. Because he was very bright, was a powerful and accurate calculator, and possessed outstanding communication skills, Fred

FREDRIK ZACHARIASEN

was a valuable collaborator; much of his work was with others.

Fred's early work involved the use of photons to probe the strong interaction through form factors, meson production, and the role of the π–π interaction in these processes. Much of this work was in collaboration with Sid Drell. This period also marked the beginning of Fred's collaboration with Marshall Baker, a collaboration that lasted for 40 years.

After Murray Gell-Mann joined the Caltech faculty, he became one of Fred's frequent collaborators. At the time, Regge poles and trajectory were of great interest, but their existence was based on nonrelativistic quantum mechanics. In an important series of papers, Fred and his colleagues Gell-Mann, Marvin Goldberger, and Francis Low showed that conventional field theory produced Regge poles.

By the late 1960s, particle theorists had accepted the fact that small momentum transfer processes dominated particle production, but no one had managed to figure out the kinematics that would make this possible. Fred and George Zweig showed that the particles produced had to obey an ordering in longitudinal momentum known as strong ordering. These ideas were quickly incorporated into what became the multiperipheral model, which demonstrated that the uniform distribution in rapidity is simply the result of the strong ordering requirement. Fred used to joke that his reason for collaborating with Zweig and his earlier collaboration with Charles Zemach were so that he could be the first author on at least some of his papers.

In the early 1970s, when the Fermilab accelerator and CERN's Intersecting Storage Rings began to provide data on diffractive phenomena in proton–proton scattering, Fred directed his efforts toward finding a generalization of the idea that diffraction was described by a single Regge pole. In a paper with Jerry Finkelstein and in a series of papers with James Ball, several models were developed that related particle production to diffraction in a manner consistent with basic principles.

After the invention of quantum chromodynamics (QCD) in the early 1970s, Fred began a study of its long-range behavior. Because perturbative methods could not be used in this region, Fred, working with Marshall Baker and James Ball in a collaboration known as BBZ, used a nonperturbative approach with the Schwinger–Dyson equation providing the dynamics. This technique was used in a series of papers to determine the long-range behavior of the quark–antiquark potential. In this picture, QCD at long distances behaves like a dual superconductor. This feature led to calculations of the properties of flux tubes connecting quark–antiquark pairs, the detailed spin- and momentum-dependent potentials between quarks, and predictions for states formed of heavy quark–antiquark pairs.

In spite of the fact that there were few other analytic models of long-distance QCD, the work of BBZ and the importance of understanding confinement were not generally recognized. But in the past five years, two recent developments have revived interest. First, Nathan Seiberg and Edward Witten inferred that dual superconductivity occurs in certain supersymmetric versions of QCD. Second, lattice gauge theory became powerful enough to calculate spin-dependent potentials between quarks. Fred's last particle physics paper was a detailed comparison of these results to those of BBZ, which showed remarkable agreement.

Fred's other research activities stem from his many years as a member of the JASON group, which provides technical advice on national security issues to the government. Although he didn't always agree with military and government policies and actions, Fred felt that JASON provided a badly needed voice of reason within the establishment. An outgrowth of his JASON work was research in oceanography, first with Stanley Flatté and later with Walter Munk.

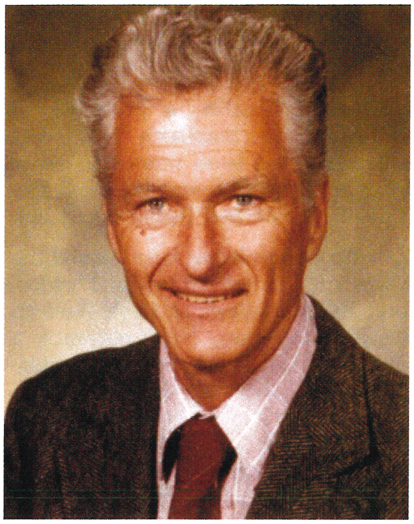
Fred's only major venture into administration was in 1981, when he accepted a position as associate director of Los Alamos National Laboratory. Because he was very well organized, Fred hoped that he could handle this assignment while maintaining his research activities. He soon realized that not only did he not have time for research, but the more modest goal of improving the scientific activities of the lab was also out of reach. The following year he returned to his position at Caltech.

Fred lived life to the fullest. He loved to travel and, despite being terrified of flying, joked that he had flown about one mean free path on airplanes. His other main hobbies were outdoor activities and photography, and he was proud of the many pictures of his travels and hikes with his wife Nancy and their daughters, Kerry and Judy.

Throughout his life Fred struggled with asthma and other health problems. While this did at times limit his activities, he maintained his enthusiasm for life and work. In fact, he appeared to take his health difficulties so lightly that his many friends and colleagues were shocked by his sudden death. He will be sorely missed.

Marshall Baker
University of Washington
Seattle, Washington
James S. Ball
University of Utah
Salt Lake City, Utah
Marvin Goldberger
University of California, San Diego
La Jolla, California

James Edward Zimmerman



James Edward Zimmerman

James Edward Zimmerman, coinventor of the radio-frequency superconducting quantum interference device (SQUID), died 4 August 1999 in Boulder, Colorado, after battling cancer for three years.

Born on 19 February 1923 in Lantry, South Dakota, Jim grew up on a ranch on the desolate, windswept prairie. According to his recollection, he spent much of his childhood keeping coyotes away from his family's sheep. While in high school, however, he became fascinated with radio and spent his spare time building receivers and transmitters from scavenged parts.

In 1943, having earned an electrical engineering degree from the South Dakota School of Mines and Technology, Jim joined the Westinghouse Research Laboratory in Pittsburgh to work on microwave radar as part of the war effort. This job eventually took him to Sydney, Australia, where he helped the Australian radar program.

After the war, Jim returned to Pittsburgh and completed his education with a PhD in physics from the Carnegie Institute of Technology. His thesis, completed in 1951 under Immanuel Estermann, concerned the thermal properties of materials at low temperatures and established a cryogenic theme that would dominate the remainder of his career. He remained at Carnegie Tech as a research associate for two years after receiving his doctorate.

Jim took a brief detour from cryogenics, when he joined the Smithsonian Institution in 1953; he spent two years measuring the solar constant at observatories in California and Chile.

In 1955, Jim joined the low-temperature group at Ford Motor Co's Scientific Laboratory in Dearborn, Michigan. During his first eight years at Ford, he measured the thermal, electrical, and magnetic properties of metals and alloys at low temperatures. In the early 1960s, however, his work changed direction dramatically as he became involved in experiments on quantum interference in superconductors.

In 1963 John Rowell of Bell Telephone Laboratories had observed a diffraction pattern in the magnetic response of a Josephson tunnel junction. And in 1964, Robert Jaklevic, John Lambe, Arnold Silver, and James Mercereau of Ford had demonstrated two-slit interference in a superconducting loop interrupted by two junctions. Characteristically, Jim believed that interference could be realized with simpler apparatus. Before the end of 1964, he demonstrated a two-junction interferometer consisting simply of two U-shaped bits of niobium wire pressed together. Later, Jim refined this approach by developing adjustable point-contact junctions that became the staple of early interferometers.

In 1965 Jim and Silver realized that quantum interference could be observed in a superconducting loop with a single junction if it was excited by a radio-frequency bias. Jim conceived of this circuit as an analog of the class-C amplifier familiar to him from his high-school radio days. The single-junction circuit was an immediate success, yielding a fully practical magnetometer/amplifier with exquisite sensitivity, limited only by the uncertainty principle.

Shortly after the invention of the single-junction interferometer was announced, Jim suggested SQUID as an acronym for superconducting quantum interference device. The term stuck, recently becoming an entry in the Oxford English Dictionary.

The remainder of Jim's career was devoted to the further development of SQUID technology and applications. In 1969 he left Ford to help found a company called SHE (now BTI), which manufactured the first commercially successful radio-frequency SQUIDs, based on his point-contact design.

In 1970 Jim joined the National Bureau of Standards (now NIST) in Boulder, Colorado, and began to explore the application of SQUIDs in both measurement science and biomagnetism.

On New Year's Eve of 1969, Jim participated in an historic experiment, conducted at MIT in collaboration with David Cohen and Edgar Edelsak. This experiment, which recorded the first human magnetocardiogram using a SQUID sensor,