Steven Weinberg

to measure the isotopes and elements in energetic cosmic-ray nuclei and to study the magnetospheres of the outer planets and their satellites. These instruments detected the energetic sulfur and oxygen ions near Jupiter's volcanically active moon Io. Stone has helped develop a large-area instrument to measure from a satellite the abundance of rare, heavy Galactic cosmic-ray nuclei, and he has worked on the Gamma-Ray Imaging Payload, a balloon-borne gamma-ray telescope. He is also the principal investigator for the Advanced Composition Explorer, scheduled for launch in 1997, which will measure isotopic and elemental compositions of matter in space.

Stone earned his physics PhD from the University of Chicago in 1964. He then joined the faculty of Caltech, where he is a professor of physics. He was chairman of the physics, mathematics and astronomy division there from 1983 to 1988. He has been director of JPL since 1 January 1991. He is a member of the board of directors of the California Association for Research in Astronomy, the group responsible for building and planning the Keck Observatory in Hawaii.

Weinberg's citation lauded "his contribution to the discovery of the structure of the fundamental forces of nature, the development of the standard model and unification of the weak and electromagnetic forces." In 1967 Weinberg, and independently in 1968 Abdus Salam, developed a field theory that unified the electromagnetic and weak interactions as components of a single field. The theory, anticipated in part in earlier work of Sheldon Glashow, used an exact $SU(2) \times U(1)$ gauge symmetry that is spontaneously broken by the Higgs mechanism. The breaking of the symmetry results in electromagnetic interactions mediated by the massless photon and weak interactions mediated by the massive gauge bosons, $W^{\pm}$ and Z^0. Weinberg predicted the masses of the W and Z particles in terms of a weak mixing angle, θ_W, as well as the existence of weak neutral currents. The theory was proven in 1971 to be renormalizable; weak neutral currents were found in 1973; and the W and Z particles were discovered in 1983, confirming the essential elements of the theory, which is now called the standard model of electroweak interactions.

Weinberg has also worked in many areas of elementary-particle theory and cosmology and has helped plan the Superconducting Super Collider. He has written the textbook *Gravitation and Cosmology* and the books *The Discovery of Subatomic Particles* and *The First Three Minutes: A Modern View of the Origin of the Universe*, the last of which won a wide popular audience.

Weinberg received his PhD in physics from Princeton University in 1957. He worked at Columbia University for two years, then went to the University of California's Radiation Laboratory in Berkeley. In 1960 he became a physics professor at the University of California, Berkeley. From 1969 to 1973 he was on the faculty of MIT, after which he went to Harvard University. Since 1982 he has been a professor of physics and astronomy at the University of Texas, Austin. He shared the 1979 Nobel Prize in Physics with Glashow and Salam for work on the standard model.

James J. Duderstadt

In receiving the technology medal, Duderstadt was commended for "his excellence in the development and implementation of strategies for engineering education," as well as for "his successes in bringing women and minorities into the nation's technological work force." Duderstadt's research topics have included theory and design of nuclear reactors using both fission and fusion systems; neutron transport theory; kinetic theory and statistical mechanics; the interaction of laser beams with dense plasmas; high-power lasers; and computer simulation.

A physicist and engineer by training, Duderstadt got his PhD in physics from Caltech in 1967. For two years after that he worked at Caltech as a postdoc for the US Atomic Energy Commission. In 1969 he joined the faculty of the University of Michigan, where he is currently a professor of nuclear engineering. Duderstadt was dean of the college of engineering from 1981 to 1986, when he became provost and vice president of academic affairs at the university. He has been president of the university since 1988.

AAS DIVISION AWARDS GIVEN TO RESEARCHERS

Two divisions of the American Astronomical Society—the division on dynamical astronomy and the division for planetary sciences—have announced the 1991 recipients of several awards.

The division on dynamical astronomy has chosen Martin Schwarzschild of Princeton University to receive its 1991 Brouwer Award. Schwarzschild is cited for his "outstanding contributions in the field of dynamical astronomy applied to star clusters and galaxies" and also his role as "teacher and mentor, vice president of the IAU and president of the American Astronomical Society." Schwarzschild invented a simple numerical technique, now known as the Schwarzschild method, that has led to greater understanding of the equilibrium structure of elliptical galaxies.

Schwarzschild earned a PhD in astronomy from the University of Göttingen in 1935. After holding positions at the University of Oslo, Harvard and Columbia, he joined the Princeton faculty in 1947. He is currently the emeritus Higgins Professor of Astronomy there.

At the November meeting of the AAS division for planetary sciences, the Kuiper Prize was given to Edward Anders of the University of Chicago. Anders was cited for "his sustained and fundamental contributions to the understanding of the chemistry of the solar system, particularly the origin and nature of organic matter in meteorites." With M. Ebihara in 1982 and N. Grevesse in 1989, Anders studied the abundances of the elements in the solar system, and he has also studied the volatile inventory of the terrestrial planets.

Anders received a PhD in chemistry from Columbia in 1954. He joined the Chicago faculty the following year, and in 1973 he became the Horace B. Horton Professor of Chemistry. He retired in 1991.

Also honored at the November meeting was Richard Binzel of MIT, who received the Urey Prize, which recognizes achievements by a scientist under 36 years. Binzel was chosen for his "observational and theoretical research on asteroids and the planet Pluto." By measuring and comparing the physical properties of various asteroid clusters, he has been able to estimate the initial conditions of their parent bodies. His observations of Pluto and its moon Charon between 1985 and 1990 are now being used to map their surfaces.

Binzel earned a PhD in astronomy from the University of Texas at Austin in 1986 and is currently an associate professor in the department of Earth, atmospheric and planetary sciences at MIT.

The division's first Harold Masursky Award, for meritorious service to planetary science, was presented to Carl Sagan of Cornell University. Sagan was cited for "his role in the overall development of planetary science, not only through his research accomplishments, but also through his service to the broader community." Sagan's research has included studies of planetary atmospheres and surfaces, and he has also played a prominent role in communicating science to the public.

Sagan received a PhD in astronomy and astrophysics from the University of Chicago in 1960. He joined the faculty of Harvard University in 1962 and moved to Cornell in 1968. He is currently the David Duncan Professor of Astronomy and Space Sciences and director of the Laboratory for Planetary Sciences.

OBITUARIES

Edwin M. McMillan

Edwin Mattison McMillan's life ended on 7 September 1991, after several years of declining health. He was just 11 days short of 84 years of age. McMillan was one of the great physicists of the middle decades of this century. He was a pioneer in the development and application of the cyclotron, he opened the way to the study and utilization of transuranic elements, and he elucidated one of the basic principles of modern high-energy accelerators.

McMillan received his BSc from Caltech in 1928 and his MSc from the same institution the following year. He studied more chemistry than was usual for a physics student and was greatly influenced by a close association with Linus Pauling, who was a National Research Fellow at Caltech at that time. Caltech had had an even earlier influence on MacMillan: As a youth he lived close by, and at an early age his budding interest in all things scientific was nourished by the excellent public programs and lectures at that institution. He continued his graduate studies at Princeton University, where he did research on molecular beams under the general direction of Edward U. Condon. He received his PhD in 1932 and was awarded a two-year National Research Fellowship.

In 1932, at the invitation of Ernest Lawrence, who the year before had founded the Radiation Laboratory at the University of California, Berkeley, McMillan came to the physics department at the university with the intention of doing an experiment to measure the magnetic moment of the proton. However, Otto Stern published his result on that experiment while McMillan was completing his apparatus, so he turned to research on hyperfine structure and published several papers in that field. He also began to take interest in the activities in the adjacent Radiation Laboratory. Nuclear physics was being transformed by a succession of startling discoveries: the neutron, the proton and induced radioactivity. McMillan was increasingly drawn to that field, and he recognized the research potential of the cyclotron.

In 1934 McMillan joined the Radiation Laboratory as a research associate and began his association with Lawrence, who early realized McMillan's profound practical and analytic abilities. That association was to last until Lawrence's death in 1958. McMillan very quickly established himself as a meticulous and versatile experimenter in nuclear physics. He discovered new isotopes: ^{15}O with Stanley Livingston and ^{10}Be with Samuel Ruben. In a program of studies of gamma rays accompanying nuclear disintegrations, particularly from fluorine bombarded by protons, he provided the first unambiguous verification of electron-pair production. He took a keen interest in the operation and development of the cyclotron, then an almost entirely empirical art. He helped to rationalize the understanding of cyclotrons and was responsible for important improvements in magnetic field shaping, ion sources, beam extraction, and power and control systems. He played an especially valuable role in the construction and initial operation of the 60-inch cyclotron in 1939.

McMillan's teaching career began in 1935, when Raymond T. Birge, then the chairman of the physics department at the university, recognized his talents and secured for him an appointment as an instructor there. By 1946 he had become a full professor.

McMillan possessed a broad spectrum of capabilities. He had a command of both theoretical and experimental nuclear physics. He was comfortable dealing with large, complex equipment. But the activity he loved best was conducting very simple but significant experiments and then thoughtfully interpreting the results. An example of this approach led to the discovery of neptunium. With the news early in 1939 of the discovery of fission by Otto Hahn and Fritz Strassman, McMillan undertook a simple experiment: He measured the range of fission fragments by their penetration of a stack of foils in contact with a thin layer of a uranium compound exposed to neutrons from a cyclotron target. But McMillan did more. He examined the uranium layer and found a known 23-minute activity (^{239}U) and a previously unknown 2.3-day beta activity. He immediately suspected that the 2.3-day activity was a beta-decay product of the 23-minute uranium activity and therefore had to be an isotope of element 93. Chemical separation of the new activity from uranium proved to be very difficult. McMillan enlisted the help of Philip Abelson, who had been working on uranium activities and was visiting at the university at that time. They successfully accomplished the separation in the spring of 1940, and so established the existence of the first transuranic element, which they named neptunium.

The daughter product of neptunium, for which the name plutonium was reserved, was expected to be an alpha-active isotope of element 94. McMillan and Abelson did observe an alpha activity, but it was too weak for proper analysis. McMillan produced a stronger alpha activity in uranium bombarded with 16-MeV deuterons. However, the disruption of the world of physics by World War II was beginning, and McMillan left Berkeley for the first of several wartime