tant of Jack's contributions. He made many more that are too numerous to mention.

Jack's solar physics interests were broad. He led two eclipse expeditions to observe the height-resolved chromospheric spectrum. The first, to Khartoum in 1952, helped to establish the relative temperatures of the solar chromosphere and photosphere. For the second expedition, to Puka Puka in the South Pacific in 1958, he designed two slitless spectrographs and a jumping-film camera. And starting in 1960, Jack made detailed investigations of small-scale motions in the solar atmosphere (especially the five-minute oscillations). He produced the first quantitative measurements of the velocity amplitudes as a function of line strengths and levels in the solar atmosphere.

He was also especially interested in flare mechanisms. In 1958, he obtained the first photographic data of sufficient time resolution to reveal how sunspot magnetic fields change during flares.

During his long career, Jack received many awards from academia and from the Air Force, but his achievements and honors only partially reflect his outstanding human qualities. As observatory director, he nurtured the careers of countless young solar astronomers, whether staff members or visitors. Combined with his scientific achievements, these special qualities were responsible for his powerful impact on the national and international solar communities.

The John Evans Solar Facility in Sac Peak bears a commemorative plaque that fittingly reads:

> Named in honor of the first Director (1952–1975) of Sacramento Peak Observatory, who transformed a remote mountain-top observatory into a world-renowned center for solar astronomy. August 18, 1987.

His legacy continues.

Richard B. Dunn
Raymond N. Smartt
Jack B. Zirker
National Solar Observatory
Sunspot, New Mexico

Kenneth Alan Johnson

Kenneth Alan Johnson, an innovative theorist in the field of elementary particle physics and a physics professor at MIT for 40 years, died in Cambridge, Massachusetts, of cancer on 8 February 1999.

Born in Duluth, Minnesota on 26 March 1931, Ken graduated in 1952 with a BS degree from the Illinois Institute of Technology. He did his graduate work at Harvard University, where he earned an AM and PhD in 1954 and 1955, respectively. His PhD thesis, supervised by Julian Schwinger, bore the title "The Quantum Electrodynamics of the Scalar Field."

Ken remained at Harvard as a research fellow and lecturer before taking up a National Science Foundation fellowship at the Institute of Theoretical Physics in Copenhagen in 1957. In the fall of 1958, he joined the MIT physics faculty as an assistant professor and was promoted to full professor in 1965.

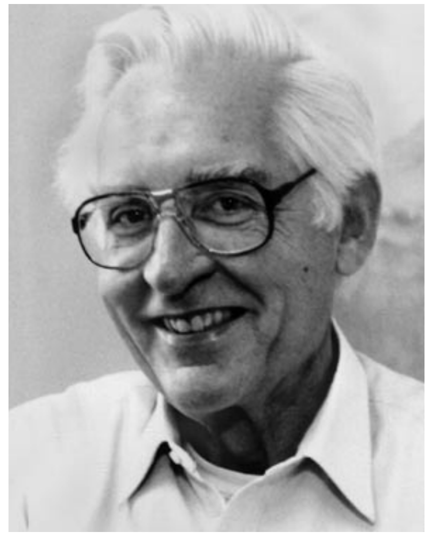
Ken's early work, much of it in collaboration with Marshall Baker, was largely devoted to the short-distance behavior of quantum electrodynamics. Together, he and Baker studied the implication of finite renormalization constants, and, in 1979 published an early discussion of anomalies in quantum field theory.

In the early 1960s, Ken worked on the covariance of the time-ordered product in quantum field theories. His discovery of noncanonical behavior presaged later developments, such as the operator product expansion and perturbation theory anomalies.

In 1967, together with Francis Low, Ken introduced the short-distance limit (now known as the Bjorken-Johnson-Low limit) and used it to explore commutator anomalies in perturbation theory. Both the method and the results influenced the development of deep inelastic physics over the decade that followed.

In 1971–72, during a Sloan- and Guggenheim-supported sabbatical at the Stanford Linear Accelerator Center, Ken became fascinated with quark confinement in quantum chromodynamics. When he returned to MIT, he began an intense and fruitful collaboration with a group of young colleagues—Alan Chodos, Bob Jaffe, Charles Thorn—and the not-so-young Viki Weisskopf. This collaboration led to the so-called MIT bag model.

Incorporating aspects of the parton model and hadronic string theory, the bag model provided a practical description of confined quarks with weak interactions at short distances. Ken masterfully brought the artillery of quantum field theory to bear on quark phenomenology. In the early 1970s, he and his collaborators wrote a series of papers using the bag model



KENNETH ALAN JOHNSON

to explore and explain many aspects of quark and gluon dynamics. The group made fundamental contributions to our understanding of hadron spectroscopy, nucleon structure, glueballs and exotics, Reggeons, and chiral dynamics. It is now believed that the bag model provides a phenomenological first approximation to light quark dynamics.

Characteristically, Ken was not satisfied with a phenomenological description of confinement. In the 1990s, he repeatedly reformulated QCD, searching for gauge-invariant field coordinates in terms of which the principal features of confinement would be manifest. He was guided by his deep understanding of QCD as he attempted to put the mechanism of confinement in more precise mathematical terms. As always, he built on a simple and intuitive notion—namely, that if observable states in a non-Abelian gauge theory were colorless, then one must be able to describe their spectrum better if the Hamiltonian is recast in gauge-invariant variables. Ken developed this idea with Peter Haagensen.

Another brainchild of Ken's later years was the method of differential renormalization. This approach emerged from a lunchtime discussion with Dan Freedman in which Ken claimed that a practical method existed to regulate Feynman diagrams directly in position space. When challenged, he proudly came back the next day with a simple formula that did the job and that he further developed in collaboration with Freedman, Peter Haagensen, and José Latorre.

In this project, as always, Ken's insight and profound knowledge of physics inspired everyone around him, but so did his optimism and positive outlook on life. His office door was always open, and he was always ready to help his colleagues in their work. His judgment and advice were always helpful. Ken was widely respected and admired. He will be sorely missed.

Daniel Z. Freedman
Robert L. Jaffe
Francis E. Low
Massachusetts Institute of Technology
Cambridge, Massachusetts
Marshall Baker
University of Washington
Seattle, Washington

Jose Roberto Manzano

Jose Roberto Manzano

Jose Roberto Manzano, an Argentine pioneer in space physics, died of a heart attack on 26 September 1999 in Tucumán, Argentina.

Roberto, as he was known to his family and closest friends, was born in Tucumán on 11 February 1928. He earned his *licenciado en fisica* (a degree equivalent to midway between a US bachelor's and master's degree) at the National University of Tucumán (UNT) in 1954 and at the University of Buenos Aires in 1955. (To start a PhD at Buenos Aires, he needed a *licenciado* from the same university.)

Roberto's scientific career began in 1954 as an investigator at Argentina's National Commission of Atomic Energy. It was during his tenure at the commission that he initiated the study of cosmic radiation in Argentina.

In 1961, he became an assistant professor at UNT, where he founded and managed the university's Cosmic Radiation Laboratory in collaboration with Orestes Santochi. He designed, built, and installed instruments to measure cosmic radiation, thereby initiating the modern study of cosmic rays in Argentina.

In 1963, he earned his *doctor en ciencias fisicas* (equivalent to a PhD) from the University of Buenos Aires with a dissertation entitled "Spatial Asymmetry in Cosmic Radiation Modulation Mechanisms during Forbush Decreases."

In 1963, Roberto moved to the University of Minnesota to study cosmic rays and space physics with instruments carried on rockets and balloons. But a year later, he returned to Argentina to become a professor at UNT. Between 1970 and his death, he directed UNT's Ionospheric Laboratory. Most of the investigators currently working at the laboratory obtained their doctorates under his guidance, which he also extended to a large number of undergraduate students who gained their first research experiences in his lab. He also helped to create UNT's school of atmospheric physics, and was its first academic director from 1997 until his death.

Roberto's major contribution was in understanding the behavior of the ionospheric F region and magnetic storms and substorms. Just before his death, he investigated the coupling mechanisms between different atmospheric regions.

In 1980, Roberto became a principal investigator at Argentina's National Council of Research (CONICET), and in 1994 he was promoted to the position of superior investigator. He also served as the director of the physics department, as UNT's dean of research, and on several UNT and CONICET councils. Roberto also acted as an adviser to the National University of Córdoba, the National Education Ministry, the National Commission of Space Research, the International Institute for Environmental Earth and Marine Science, and the International Center for Earth and Environmental and Marine Science and Technologies. In addition, he played an active role in the creation of the Latin American Association of Space Geophysics (ALAGE).

Roberto was always ready to listen to his students and his collaborators, and to talk about any topic—even our personal problems. He will be missed by those who experienced his warm personality and inquiring spirit.

Olga Pintado
National University of Tucumán
Tucumán, Argentina ■