and Bob often took a contrary position. Although sometimes infuriating to others, his contrary stance often proved crucial. He liked to undertake difficult experiments, breaking new methodological ground.

Bob did not change his lifestyle because of his diagnosis of lung cancer two years before his death. He continued to collect data and write computer programs. He died peacefully, surrounded by his wife and children. Bob will be remembered for his compassion, his integrity, and his honesty.

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Rein Silberberg

Rein Silberberg, who was widely admired among his colleagues for his research on the propagation and origin of cosmic rays, died of cancer on 31 August 2001 in Silver Spring, Maryland. His productive career, spanning four decades, was spent at the Naval Research Laboratory (NRL) in Washington, DC.

Rein was born in Tallinn, Estonia, on 15 January 1932. In the aftermath of World War II, his family migrated to Finland, then to Sweden, and then to Canada. In 1950, they arrived in the US. As a boy, Rein attended school in each of those countries, becoming fluent in their languages. In later years, linguistics was one of his hobbies.

At the University of California, Berkeley, Rein joined the group of Emilio Segrè. Guided by Gerson Goldhaber, he studied the interactions of the recently discovered antiprotons, using nuclear emulsions for detection. Rein received his MA in physics in 1956 and his PhD in physics in 1960, both from Berkeley.

As a National Research Council postdoctoral research fellow, he was attracted to the Laboratory for Cosmic Ray Physics at NRL. For Rein, it was a seamless transition. The cosmic-ray lab, founded by one of us (Shapiro) in 1949, had developed advanced techniques for processing stacks of thick photographic emulsions, and had set up a well-equipped microscopy lab for the analysis of particle tracks. These methods were being applied to problems in elementary particle physics and cosmic rays.

Rein took advantage of these facilities, participating in the early 1960s in high-altitude balloon experiments that established the relative abundances of helium-3 and helium-4 in the primary cosmic radiation. The result confirmed the value of the mean-free-path of Galactic cosmic rays, which had been deduced in a prior experiment, by the NRL group, on the relative abundance of the elements lithium, beryllium, and boron among the primaries. The observations had revealed that the "primary" cosmic-ray nuclei must include a substantial component of secondaries. Secondaries were fragmentation products resulting from collisions of parent nuclei in the tenuous gas of the interstellar medium. The question arose: What do the cosmic rays look like when they are first accelerated? With us (Shapiro and Tsao), Silberberg embarked on a program of investigations that revealed the source composition of cosmic rays. This composition provides the principal clues to the origin of the high-energy particles.

The studies also predicted the isotopic composition of the cosmic rays arriving in the vicinity of Earth; this prediction was subsequently confirmed in experiments by other investigators. Another advance flowing from this work was the development of methodology for estimating the "age" of cosmic rays, that is, their mean residence time before escape from the Galaxy.

The program on the propagation and transformation of cosmic rays in the interstellar medium needed cross sections for the breakup of relativistic heavy nuclei into lighter ones. No theoretical, and very few experimental, values of these cross sections were available. In 1967, Rein developed a set of semiempirical equations for deducing the cross sections. Steadily revised and improved for many years (in the light of new measurements at accelerators), these Silberberg–Tsao equations have been an essential and widely used tool for elucidating the propagation and source composition of cosmic rays. Rein was also among the pioneers who showed the importance of cosmic-ray reacceleration.

Rein was active in the nascent field of theoretical neutrino astronomy. Collaborating with one of us (Shapiro) in Project DUMAND (deep underwater muon and neutrino detection) from 1975–85, he calculated the prospects of identifying promising celestial sources of high-energy neutrinos. From 1966 to 2000 at NRL, Rein also contributed to the science of radiation effects, including biological effects of cosmic rays and other radiations, energy deposition by nuclear interactions, and formulation of radiation protection requirements for a lunar base and for manned missions to Mars. This work helped the computer industry and the defense community.

REIN SILBERBERG

By sheer resolve, Rein did not let his physical handicaps impede his productivity. He served for many years as associate director and lecturer in the International School of Cosmic-Ray Astrophysics at the Majorana Center in Erice, Italy.

Rein was generous and considerate to a fault. Despite his single-minded dedication to research, he always found time to help friends and especially younger scientists. Integrity is surely a sine qua non of scientific research; Rein possessed this quality to an admirable degree. He enjoyed spending time at his mountain retreat with his wife Ene and children Hugo and Ingrid. We feel fortunate that he was our friend and collaborator.

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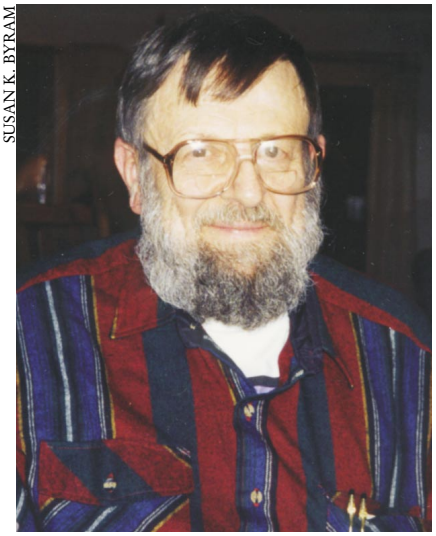
Robert Allen Sparks

Robert Allen Sparks, an x-ray crystallographer who contributed greatly to the use of computers in his field, died with his wife Nonie on 29 July 2001 in a traffic accident on State Route 6 near their home in Tillamook, Oregon. They were returning home after attending the annual American Crystallographic Association (ACA) meeting in Los Angeles.

Born on 16 August 1928 in Hollywood, California, Bob was a friendly, soft-spoken man, passionately interested in crystallographic methods, and liked and respected by all. He pos-

SUSAN K. BYRAM



ROBERT ALLEN SPARKS

sessed an infectious enthusiasm for crystallography and great patience for anyone willing to learn it. Bob received his BS in 1950 and MS in 1953, both in chemistry, from UCLA.

While at UCLA, with Ken Trueblood, Bob was involved in the early computational stages of determining the chemical formula of vitamin B_{12}. Under Trueblood's direction, Bob, as a graduate student early in 1954, helped write the computer programs for the National Bureau of Standards SWAC computer that enabled calculation of electron-density maps for vitamin B_{12}. This work, writing programs for binary-coded punch cards in assembly language, was highly significant in the days when computers were simply glorified adding machines.

In the early 1950s, the structure of vitamin B_{12} was the largest one of unknown chemical formula (93 nonhydrogen atoms) to be tackled. Trueblood, anxious to try out these computations on large structures, contacted Nobel laureate Dorothy Crowfoot Hodgkin at Oxford University. She sent experimental data and Bob, with Trueblood, Dick Prosen, and others, worked through many nights on the computer to produce B_{12} maps. They replaced, when necessary, the vacuum tubes in SWAC, which had a 20-minute mean time between failures. The structure of the hexacarboxylic acid, which established the ring structure of vitamin B_{12}, was published by Hodgkin and others in *Nature* in 1955, and the air-dried and wet native B_{12} structures, which Bob worked on, were published in various publications during the period 1959 to 1962.

Bob received his PhD in 1958 from UCLA under the direction of Trueblood. Bob's thesis was entitled "I. Refinement of Crystal Structures. II. The Structure of Anthracene and Naphthalene. III. The Structure of Postassium Chlorate." He then became an NSF postdoctoral fellow at Oxford in Hodgkin's laboratory, where he wrote a program to locate the 88 hydrogen atoms in the structure, a final confirmation of the chemical formula reported by Hodgkin and coworkers.

Bob cofounded Syntex Analytical Instruments in 1969 to develop computer-controlled x-ray diffractometers. That company, together with California Scientific Systems, which he cofounded in 1978, evolved into Bruker AXS, where Bob remained a driving force behind the development of more than 1000 diffractometers and charge-coupled device instruments for crystallography. He consistently strove to make the software easier to use and accessible to nonexperts, even as the instruments grew capable of solving larger and more complex structures. Several generations of instrument users consider him their mentor. While at Syntex, he also contributed to the development of computer-aided tomography scanners, and later to the development of the Imatron CT heart scanner widely used in hospitals today. A primary interest of his was the development of computer graphics programs to facilitate crystal structure determination and analysis; he presented a set of future plans for such work at the Los Angeles ACA meeting.

Bob's work on crystal structure determination was combined with important contributions to the teaching of x-ray crystallography. He persuaded Trueblood to propose with him a national course for teaching crystallography. This proposal resulted in the annual ACA summer school in crystallography. Bob was codirector of the school for 10 years, from its inception in 1992, when it was held at the University of Pittsburgh, until it moved to its present location at the University of Georgia in Athens, where he actively taught during the summer of 2001 just before the ACA meeting in Los Angeles. The summer courses have been great successes; to date, about 407 students have attended. Bob also served as the treasurer of ACA from 1980 to 1985.

A symposium in his honor had been planned for the next ACA meeting in San Antonio, Texas. Bob had been informed of this honor and was delighted. The symposium will now be in San Antonio on 26 May 2002 as a memorial tribute to a man who has influenced and was admired by so many crystallographers.

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Thomas Howard Stix

Thomas Howard Stix, an original thinker in plasma physics and one of the field's leading developers, died of leukemia on 16 April 2001 in Princeton, New Jersey. He was a professor emeritus in astrophysical sciences at Princeton University.

Tom was born in St. Louis, Missouri, on 12 July 1924. He served in the US Army Signal Corps from 1942 to 1945. He received his BS in physics from Caltech in 1948 and his PhD in physics from Princeton in 1953. His doctoral thesis, under Ronald R. Rau, was entitled "Heavy Nuclei in the Primary Cosmic Radiation: Investigation at Balloon Altitudes by Cloud Chamber and Proportional Counter Telescope."

After receiving his doctorate, Tom joined Project Matterhorn, then a small classified project on Princeton's Forrestal campus, aimed at harnessing fusion energy for peacetime use. Under the leadership of Lyman Spitzer, Project Matterhorn grew rapidly. In 1961, during the time Tom was heading the experimental division, the project's name was changed to the Princeton Plasma Physics Laboratory.

An early assignment at Project Matterhorn in 1956 brought Tom to the problem of plasma heating by radio frequency (RF) waves. Spitzer had proposed a low-frequency scheme called magnetic pumping. An early fusion device, the B-64 stellarator designed and built by Tom, exhibited

THOMAS HOWARD STIX