

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 mis-



REIN SILBERBERG

sions to Mars. This work helped the computer industry and the defense community.

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-