cid expositions in five books, *The Stars: Their Structure and Evolution* (Wykeham, 1970), *The Origin of the Chemical Elements* (Wykeham, 1972), *Galaxies: Structure and Evolution* (Wykeham, 1978), *The Hidden Universe* (Ellis Horwood, 1991) and *The Sun as a Star* (Cambridge University Press, 1996) are now a legacy of his clarity of mind. Those who knew him will remember him for his sense of fairness, his kindness and his compassion. He was a man of high moral stature, whose death is mourned by all those who ever met him.

DOUGLAS GOUGH
University of Cambridge
Cambridge, England

Richard Nathaniel Watts

Richard Nathaniel Watts, whose thesis research first demonstrated the use of laser diodes for the cooling of atoms, died of AIDS in Washington, DC, on 16 November 1996. He was 39 years old.

Rich was born in Waco, Texas. He received his BA, *magna cum laude*, from Rice University in 1979, and his MA and PhD in physics from the University of Michigan in 1981 and 1986, respectively. For his thesis, he worked with Carl Wieman after Wieman and his group had moved to JILA in Boulder, Colorado. Rich did postdoctoral work at the State University of New York at Stony Brook and at the National Institute of Standards and Technology (NIST) facility in Gaithersburg, Maryland, between 1986 and 1990, joining NIST permanently as a member of the electron and optical physics division in 1990.

Watts and Wieman demonstrated that a relatively simple, frequency-chirped diode laser could slow and cool an atomic beam, thus making laser cooling experiments accessible to an increased number of researchers. Before then, the only neutral atom to have been cooled was sodium. Rich added cesium and, in his postdoctoral work with Hal Metcalf at Stony Brook, extended the list by adding rubidium, also through the use of a diode laser.

While a postdoc at NIST, Rich was involved in a second important revolution in laser cooling: the discovery of what has come to be called sub-Doppler cooling. He and his NIST coworkers discovered that the low-temperature limit of laser cooling could be much lower than had been predicted by the widely accepted theory. To help validate their result, Rich took on the responsibility of developing a critical part of the experiment: new, reliable methods of determining the temperature. To that end, he led his coworkers in devising four different techniques by which to measure the extremely low temperatures.

Subsequent to his work on laser cooling, Rich branched out into extreme ultraviolet optics. He developed instrumentation and measurement methods needed for the characterization of multilayer mirrors.

Rich was a superb colleague. To his work as a scientist he brought a wonderfully high energy and an ability to get to the heart of problems quickly and seemingly without effort. Exceptionally thoughtful, loyal and generous, he approached life with consistently good humor and could illuminate almost any subject, scientific or otherwise, with his witty and insightful observations. All those who knew and worked with him were very lucky to have such a bright and lively spirit in a friend and colleague. We deeply regret it was for much too short a time.

WILLIAM D. PHILLIPS
TOM LUCATORTO
National Institute of Standards and Technology
Gaithersburg, Maryland

Paul Adams Beck

Paul Adams Beck, professor emeritus of metallurgy at the University of Illinois at Urbana-Champaign, died on 20 March 1997, in Urbana, Illinois. His career extended over some 60 years, spanning the area between metallurgy and solid state physics.

Paul was born in Budapest on 5 February 1908. He studied in the US in the late 1920s, receiving an MS in metallurgy from Michigan Technological University in 1929. He received a master's degree in mechanical engineering at the Budapest Polytechnic Institute in 1931. In the subsequent years, he had research appointments, first at the Kaiser Wilhelm Institute for Metallurgy in Berlin (with Michael Polanyi) and then at the University of Paris (with Pierre Auger).

After working for several Hungarian companies, Paul returned to the US in 1936 and was a research fellow at Michigan Technological University; a research metallurgist at the American Smelting and Refining Corp in New Jersey from 1937 to 1941; a chief metallurgist at the Beryllium Corp in Pennsylvania, from 1941 to 1942 and a superintendent of the metallurgy laboratory of the Cleveland Graphite Bronze Co from 1942 to 1945. In 1945, he became a professor of metallurgy at Notre Dame University and was later head of that department. In 1951, he

became professor of metallurgy at the University of Illinois and held that position until his retirement in 1976. Even after retirement, he continued his research in alloys and published into the late 1980s.

Research on recrystallization, grain growth and textures in deformed metals and alloys occupied a major period of his life, from the late 1920s into the 1960s. His work had a large impact on the industrial processing of alloys, especially in the high-strength, low-alloy steels and later in materials for nuclear reactors. Although many refinements naturally ensued, the fundamental principles from Paul's work still are important.

From the time he arrived in Illinois, Paul's latent interest in the electronic nature of metallic alloys blossomed, partly as a result of his association with theorists and low-temperature scientists in the physics department. He developed a strong effort in measuring the density of states at the Fermi level of alloys in the 3-d series using the low-temperature specific heat as a tool. He and several students painstakingly measured the specific heats of closely spaced solid solution alloys (atom-by-atom solutes—not compounds) across the 3-d series. The result of their work showed great spikiness of the density of states—I recall that reviewers of his papers could scarcely believe the rapid variation with electron-to-atom ratio. But, I recall also that the spikiness was if anything understated by the work.

Paul accompanied this work with research on the structure and properties of compounds. Part of this research involved precipitated phases that cause troublesome embrittlement in specific transition-metal alloys and part involved their magnetic character. Eventually, Paul switched his work over, nearly completely, to the low-temperature magnetic character of alloys—and that was the research that occupied the last 20 years of his career. He measured the spin-glass nature of alloys, a property that he called mictomagnetism. His last research concerned the magnetic character of ultrathin layers of iron in gold.

Few other engineer–scientists in my memory so easily spanned the field between metallurgy and solid state physics. Paul was in regular communication with the best researchers and teachers in both groups. His 175 publications were partly in materials science journals and partly in those of the American Institute of Physics. As a result, he received numerous honors from both physical and metallurgical societies. He was a member of the National Academy of Engineering.

Paul's many graduate students, postdocs and colleagues will recall all their lives the intensity of his desire to understand the nature of metallic alloys and compounds.

Charles Wert
University of Illinois at Urbana-Champaign

Shang Yi Ch'en

Shang Yi Ch'en, a professor emeritus of physics at the University of Oregon, died on 23 February 1997 after a long illness. He had achieved a distinguished career in optical spectroscopy.

Ch'en—"George" to his friends—was born in Hopei, China, on 4 March 1910. He earned a BS and MS in physics from Yenching University in Beijing in 1932 and 1934, respectively. He then became a research assistant at the National Academy of Beijing's Institute of Physics, where he measured the pressure broadening of spectral lines, a subject that was to become central to his entire research career. Under a fellowship from the China Foundation, he entered Caltech and in two years completed his PhD thesis on the broadening of rubidium resonance lines, under the supervision of Ira S. Bowen. Ch'en returned to Yenching University in 1939 and established a spectroscopy laboratory there. In 1942, when the university was closed by Japanese occupation forces, Ch'en and his family made their way to Chengtu, deep in China's southwestern interior.

In 1949, Ch'en moved to the US and joined the physics faculty of the University of Oregon, where he taught until his retirement in 1975. With his students, he conducted an active research program, studying collision-induced absorption and emission of atoms and line shifts in the presence of foreign gases. Among his most widely known work is a survey of the field, "Broadening and Shift of Spectral Lines Due to the Presence of Foreign Gases," written with Makoto Takeo and published in the *Reviews of Modern Physics* (**29**, 20, 1957). In the 1970s, he served as an associate editor of the *Journal of Quantitative Spectroscopy and Radiative Transfer*.

Shang Yi Ch'en was a productive and resourceful scholar, influential mentor, and thoughtful adviser. He will be missed very much by his colleagues, friends and former students.

Bernd Crasemann
David K. McDaniels
University of Oregon
Eugene, Oregon ■