

achieve results at thousands of locations around the globe.

The pattern of heat escaping through the ocean floor showed the highest heat flow along the crest of the mid-ocean ridge, which is located near the center lines of the Atlantic and Indian Oceans and is offset to the east in the Pacific Ocean. Lower values were registered in the deep basins and on the continental margins. Working with Richard Von Herzen at the Woods Hole Oceanographic Institution in the 1960s, Langseth was able to demonstrate convincingly that the high heat flow coincided with the separation of Earth's lithospheric plates and must have been caused by the active upwelling of the warm interior of the planet. Thus, Earth possessed a convective layer of ductile rock.

Between 1966 and 1975, Langseth directed the Apollo Lunar Heat Flow Experiment to learn if the Moon's interior was still hot and if there was relatively young volcanic activity on the Moon's surface. He developed a drill the astronauts used to insert temperature-measuring sensors into the unconsolidated regolith of dust and rock fragments at a sufficient depth to get away from the obscuring effect of the diurnal heating and cooling of the Moon's surface. In this airless environment, it was critical that the jacket of electronic thermometers be placed in direct contact with the soil to ensure a conducting pathway. The drilling and recording equipment was first sent aboard the ill-fated Apollo 13 mission. Then, on the Apollo 16 landing, an astronaut's misstep ripped apart a critical telemetry cable. However, Langseth was able to show from the subsequent Apollo 17 data that Earth's only satellite had already lost most of its original heat. The results fitted a fission model for the Moon's origin, according to which it carried away already differentiated layers of Earth relatively depleted in radioactive elements.

Langseth's recent projects quantified the flux of fluid out of the seabed as the result of the compaction of the sedimentary layer where the oceanic lithosphere is thrusting under the edge of a continent. He was able to show that this dewatering acts rapidly as the mud is squeezed in thrust sheets, and that the venting is through narrow conduits produced when the seabed ruptures along faults.

Langseth will be remembered for his keen insight into physical processes, for his tireless contributions to workshops and planning committees and for his sweet and gentle character.

WILLIAM B. F. RYAN

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Richard Tousey

Richard Tousey, the leading pioneer in solar research from space, died in Mitchellville, Maryland on 15 April 1997, at the age of 88. He carried out all his research during a 37-year long distinguished career at the Naval Research Laboratory in Washington, DC.

He was born in Somerville, Massachusetts, earned his AB in physics and mathematics at Tufts University in 1928 and his PhD in physics at Harvard University in 1933. Under Theodore Lyman, Tousey worked at Harvard on the extreme ultraviolet reflecting powers of materials.

In 1941 Tousey met Edward O. Hulburt, later the first director of research at the Naval Research Laboratory, when their sailboats were at anchor in Bucks Harbor, Maine. Hulburt invited Tousey to join him at NRL's physical optics division. This sailboat encounter set the course for solar research from space for the rest of the century.

During the war years, Tousey worked on vision through telescopes and binoculars as well as on infrared sensors for surveillance in total darkness.

With the arrival of German V2 rockets in the US, it suddenly became feasible to explore the solar ultraviolet spectrum. Hulburt suggested that Tousey build an ultraviolet spectrograph, mount it on a V2 rocket and photograph the Sun's UV spectrum from above the absorbing Earth atmosphere. The first flight took place on 28 June 1946 at White Sands, New Mexico, but the rocket crashed into the desert, and no piece of the spectrograph was ever found. A second launch on 10 October worked as planned. Many spectra were photographed at different altitudes, showing not only the existence of the Sun's UV spectrum down to 2200 angstroms but also its absorption by the ozone layer as a function of altitude.

Sounding-rocket work continued at NRL. In 1948, using thermoluminescent plates, Tousey established the existence of the chromospheric emission line of hydrogen Lyman-alpha at 1216 Å. A profile of Ly-alpha obtained by Edward Purcell and Tousey in 1960 showed the existence of the extended geocorona. In the years following, Tousey and his coworkers studied the solar UV spectrum at shorter and shorter wavelengths. They detected the allowed transitions of many highly-ionized elements and established that these lines are emitted from the hot solar corona at $1.5\text{--}2 \times 10^6$ kelvin. In 1959, the first image of the Sun in the light of Ly-alpha was obtained by Tousey and colleagues, setting the

stage for imaging the Sun in many UV lines and with high spatial resolution.

Under Tousey's direction, researchers at NRL conducted an extensive study of ultraviolet optical materials and reflecting coatings.

In 1963, together with Martin Koomey, Tousey built and flew on a sounding rocket the first coronagraph to photograph the Sun's corona from space; this instrument extended coronal observations out to 10 solar radii. The first coronagraph flew in space aboard a satellite in 1971, and was followed by several others. In his last days, Tousey was able to see on the Internet images of the solar corona transmitted by NRL coronagraphs on the Solar and Heliospheric Observatory spacecraft.

The culmination of Tousey's ultraviolet work was Skylab, flown in 1973–74 with two instruments—a large UV spectrograph and a large spectroheliograph—designed by him and his colleagues. The spectroheliograph provided a spatial resolution of 2 arcseconds. Among the numerous results of this big project was the famous HeII 304 Å image of a lifting prominence on 19 December 1973.

Tousey had many hobbies: bird-watching, restoring an old harpsichord, playing the harpsichord and sailing. Recently, he had assembled a large collection of old silver spoons. He excelled in everything that he did.

Tousey was the fastest man I ever met, almost running all the time. No obstacle was too big for him to overcome. With his deeply probing mind, he had a tremendous sense for detail, and he was a perfectionist. At the same time, he cared very much for his people, leaving room for us to develop. We at NRL will miss a great teacher, mentor and friend.

GUENTER BRUECKNER

*Naval Research Laboratory
Washington, DC*

Roger John Tayler

Roger John Tayler, who died in London of myeloma on 23 January 1997, was one of the first astrophysicists to construct realistic models of inhomogeneous stars. In his PhD dissertation, written in 1954, he discussed how stars evolve as a result of the thermonuclear conversion of hydrogen to helium, using calculations he had carried out with a mechanical, hand-operated computing machine. His work paved the way to a new level of sophistication in astrophysical modeling.

Roger was born in Birmingham, England, on 25 October 1929. After graduating in mathematics in 1950

and carrying out his postgraduate studies—both at the University of Cambridge—he spent a year as a Commonwealth Fellow at Caltech and Princeton University, and then returned home to take a position as a scientific officer at the UK's Atomic Energy Research Establishment at Harwell. There, he carried out fundamental work on the instability of plasmas in the presence of a magnetic field, as part of a program to design a method to confine intensely hot plasmas in which controlled thermonuclear fusion reactions of the kind occurring in stars could take place. The physical insight gained from these and parallel studies in the US and USSR is still relevant today, both in fusion research and in studies of magnetohydrodynamic phenomena in stars.

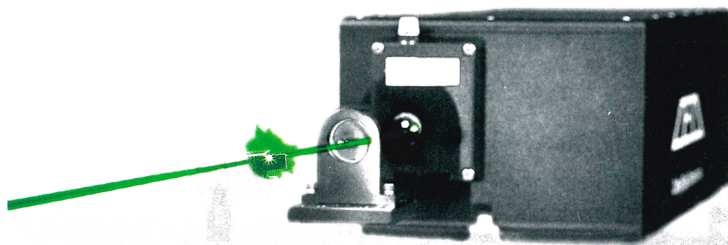
In 1961, Roger returned to Cambridge, as a fellow of Corpus Christi College, where he could devote his time more directly to astrophysics. He worked with Fred Hoyle on the origin of the chemical elements, carrying out careful calculations of the production of elements near the "iron peak" in the dense cores of highly evolved stars. He published with Hoyle a seminal paper on the production of primordial helium in the Big Bang, which linked up with significant new observations suggesting a high universal helium abundance. He stressed the importance of the neutron halflife in determining the resulting abundance.

Roger left Cambridge in 1967 to join Bill McCrea in starting the Astronomy Centre at the University of Sussex. He was an able administrator, both as director of the astronomy center for 18 years and subsequently as dean of the school of mathematical and physical sciences for 5 years. He carried out all these duties while undertaking a lecturing load far in excess of that borne by most of his colleagues at other universities, while also maintaining an active research program and supervising many graduate students. During this period, he revisited his study of plasma instability, applying it this time to stellar interiors. In addition, he served as secretary, treasurer and finally president of the Royal Astronomical Society, and for about 20 years he was managing editor of *Monthly Notices of the Royal Astronomical Society*. He was appointed an officer of the Most Excellent Order of the British Empire in 1990, and became a fellow of the Royal Society in 1995.

Roger had the remarkable ability to cut straight through obfuscation. He would extract the essence of an issue and reveal it in simple terms. This style was a hallmark both of his research and of his teaching. His pellu-

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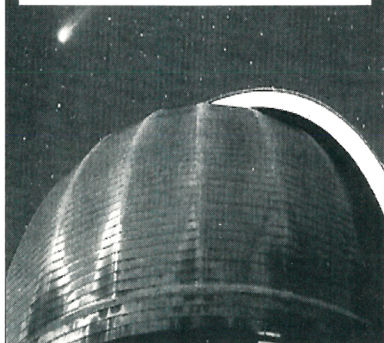
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cid expositions in five books, *The Stars: Their Structure and Evolution* (Wykeham, 1970), *The Origin of the Chemical Elements* (Wykeham, 1972), *Galaxies: Structure and Evolution* (Wykeham, 1978), *The Hidden Universe* (Ellis Horwood, 1991) and *The 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 experi-

ment: 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