the Scripps campus.

Nierenberg was rather unconventional in his approach as director. For example, he did not (as others have) support new techniques at the expense of the traditional seagoing facilities. Furthermore, he allowed beer to be served on Scripps vessels. Overall, during his tenure as director, five vessels joined the Scripps fleet.

Scripps had begun a program of measuring carbon dioxide and other greenhouse gases under Roger Revelle's directorship from 1951 to 1964. Nierenberg supported Revelle's work with enthusiasm, and intervened personally when research funds for the program were threatened. In concurrent positions as a science adviser for the President's Scientific Advisory Committee and for the White House Office of Science and Technology Policy (1969–78), he directed a study on acid rain and climate change and served on a White House panel that examined the Santa Barbara, California, oil spill of 1969.

Nierenberg did not follow conventional wisdom when it came to global warming; he vigorously said that the warming scenarios were exaggerated. He held his views so strongly that it was not easy to disagree with him. To use an analogy from ASW, Nierenberg, in exchanging information, used the principles of active rather than passive sonar, bouncing his idea off a person and observing that person's reaction.

Nierenberg, who remained closely associated with Scripps until his death, served on many governmental advisory committees; he also was a member of the JASON group. He pursued many different activities with enthusiasm and style. Among his interests were his love of France and the French language; the play *Cyrano de Bergerac* by Edmond Rostand was a favorite. Nierenberg traveled widely and was especially interested in and knowledgeable about Turkey, where he helped establish an atomic beam group at the Middle East Technical University in Ankara. Nierenberg played the balalaika, carefully tended a rose garden outside the director's office in La Jolla, and piloted his twin-engine Cessna 310.

He is missed and remembered by his many friends at UCB, at Scripps, and around the world.

CHARLES TOWNES
University of California, Berkeley
WALTER MUNK
University of California, San Diego

Frank John Kerr

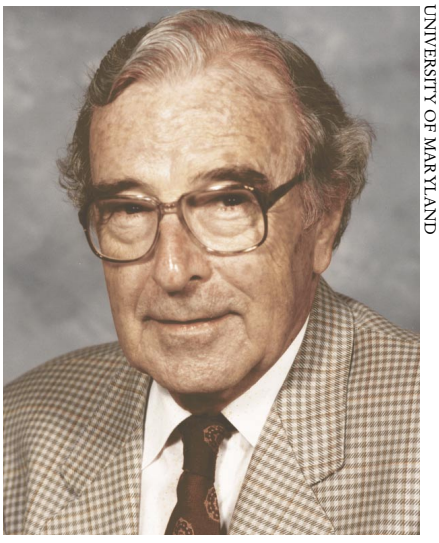
Frank John Kerr, who made major contributions to our understanding of the structure of the Milky Way, died of cancer on 15 September 2000 at his home in Silver Spring, Maryland.

Frank was born on 8 January 1918 in St. Albans, England, of Australian parents who were in England during World War I. The family returned to Australia after the war, when Frank was 1 year old. Frank received his BSc (1938) and MSc (1940) in physics at the University of Melbourne in Australia. He earned an MA in astronomy from Harvard University in 1951. He then was awarded his DSc in astronomy from Melbourne in 1962.

Frank joined the Commonwealth Scientific and Industrial Research Organization (CSIRO) radiophysics laboratory in Sydney in 1940. Of the 12 staff members at that time, he was one of the few physicists who concentrated on both theoretical and experimental fundamental science. In 1941, he put into use the "Micropup," a lightweight, air-cooled triode tube for airborne radar with 10-kW peak pulse at 450 MHz. Later, he was a key person in the use of the magnetron, and he spent the mid-1940s studying superrefraction.

Using the Radio Australia 100-kW transmitting antenna pointed at the US and a CSIRO-built receiving antenna in a shielded valley 20 miles north of Sydney, Frank obtained radio echoes of the Moon in 1948. He was the first person to conclude that serious irregularities at the top of the F2 ionospheric layer cause long-term variations in the Moon echo, and he correctly interpreted the strong short-term fluctuations as being due to lunar libration. His Moon-echo work was epoch-making. In the *Proceedings of the Institute of Radio Engineers* (volume 40, page 660, 1952), he published the classic paper on the possibility that radar echoes are reflected from the planets and the Sun. He was the first person at the radiophysics lab to specifically study astronomy, even though the group was already one of the world's leading radio astronomy organizations.

While spending a year at Harvard on a research scholarship, Frank witnessed the first detection of the 21-cm spectral line of neutral hydrogen from interstellar space. Back in Australia in late 1951, he set up the Southern Hemisphere 21-cm line program and started mapping the Magellanic Clouds. This was pioneering work—



UNIVERSITY OF MARYLAND

FRANK JOHN KERR

the first detection of a radio spectral line in an external galaxy. According to the conventional wisdom of the time, the clouds, being almost devoid of dust—especially the Small Cloud—were thought to be free of gas. Frank was undeterred by this preconception and found copious neutral hydrogen and an extended envelope around both clouds. He used a specially built 36-foot transit telescope, which at the time was the largest dish of its kind in Australia.

In 1954 and 1955, Frank, Jim Hindman, Brian Robinson, and Gérard de Vaucouleurs determined the rotation of the Magellanic Clouds and their masses—another first. Frank then started mapping the galactic disk, publishing the southern part of the disk shortly after the 1955 publication of the "Dutch map" of the Northern Hemisphere by Gart Westerhout and Maarten Schmidt. He observed that the upswing of the hydrogen layer in the northern part of the Galaxy was mirrored by a downswing in the southern part.

Frank coined the term "galactic warp" to suggest the distorting effect of the Magellanic Clouds' gravity on the shape of our galaxy. With Dutch astronomer Westerhout, Frank and Colin Gum determined the precise position of the neutral hydrogen plane. The International Astronomical Union (IAU) adopted that determination as the basis for the new galactic coordinate system. By 1960, Frank had become a leading expert in the field of galactic structure. That same year, he became a senior principal research officer at CSIRO.

Frank was heavily involved in conceptual studies for the Parkes 210-foot radio telescope and pushed for an

accurate (to 10-cm wavelength) surface for his planned 21-cm line research program. He embarked on an extensive galactic structure program when the telescope became operational in 1962. In 1966, he left Australia to join the University of Maryland, College Park, as a visiting professor of astronomy. He then became a professor of astronomy in 1968, a position he held until his retirement in 1987. But Frank did not lose interest in the Southern Hemisphere. In 1968 and 1970, he traveled to Argentina, where he amazed local astronomers with his tenacious observing. And during the 1970s, Frank and some of his students went to Australia to make a complete 21-cm survey along a 20-degree strip of the Southern Milky Way. Between 1986 and 1990, Frank successfully searched for evidence of galaxies hidden behind the Milky Way dust, and thus opened up a new and active field of research.

Frank served astronomy in many capacities: He was the chairman of the NSF advisory panel on astronomy (1971–72); director of the University of Maryland astronomy program (1973–78); councilor of the American Astronomical Society (AAS; 1972–75); and president of IAU Commission 33 (1976–79). He also was provost of the University of Maryland physical and mathematical sciences and engineering division (1978–85); AAS vice president (1980–82); chair of an IAU working group that recommended new standard values for the size and rotation properties of the Galaxy (1982–86); director of the Universities Space Research Association (USRA) astronomy and space physics division (1983–95); and chairman of the USRA Council of Institutions (1984–85).

Frank was a leader, adviser, innovator, and mentor for his scientific colleagues around the world and an outstanding source of ideas. He was a renaissance man with a pleasant, self-effacing disposition belying his enormous stature.

GART WESTERHOUT
Baltimore, Maryland

John Aloysius O'Keefe

John Aloysius O'Keefe, a man considered to be the father of space geodesy, a pioneer in planetary physics, and a longtime student of tektites, died in Sioux Falls, South Dakota, on 8 September 2000, of liver cancer complicated by Parkinson's disease.

O'Keefe was born in Lynn, Massachusetts, on 13 October 1916. He graduated from Harvard University in 1937 with a bachelor's degree in astronomy and received his PhD in astronomy from the University of Chicago in 1941. His first major discovery (in 1938) was that clouds of solid carbon cause the peculiar dips in the light curve of R Coronae Borealis, the archetype of a class of carbon-rich stars.

With the advent of World War II, O'Keefe was rejected for military service because of a physical disability. Instead, he joined the US Army Corps of Engineers as a civilian and began a new career as a geodesist, producing improved maps for the war effort. In 1945, the Army Map Service was formed to carry out the COE's mapping and geodetic missions. That same year, O'Keefe was appointed to head the research and analysis branch, where he was responsible for geodetic R&D. During the 13 years he held this post, he not only made significant individual contributions to geodesy, but was a mentor who inspired his staff members.

As an astronomer, O'Keefe felt the lure of the space program. He left his position at the Army Map Service in 1958 to become the assistant chief of the theoretical division at NASA's newly formed Goddard Space Flight Center in Greenbelt, Maryland, where he spent the rest of his career. Some of O'Keefe's most influential early work at Goddard was behind the scenes. Eugene Shoemaker christened him "the godfather of astrogeology" for services on behalf of the Apollo program and especially for his key role in expanding the scope of the US Geological Survey to include other celestial bodies.

However, O'Keefe is probably best remembered for one of the very first scientific results of the space age. After analyzing the orbit of Vanguard I, only the second satellite launched by the US, O'Keefe and his coworkers announced in 1959 that Earth's gravitational field perturbed the satellite's trajectory beyond what was expected from a rotationally flattened planet; Earth showed a surprising lumpiness in the Southern Hemisphere. O'Keefe's finding, dubbed the "pear-shaped Earth," made the newspapers and even became the subject of one of Charles M. Schulz's *Peanuts* comic strips.

In 1955, two years before Sputnik was created, O'Keefe proposed that geodesists track the motion of satellites for geodetic purposes. He intended to illuminate satellite-based

JOHN ALOYSIUS O'KEEFE

retroreflectors with Earth-based searchlights. With the invention of the laser, optical tracking became feasible, and he strongly supported putting retroreflectors on satellites and on the lunar surface. At present, the LAGEOS (LAser GEOdynamic Satellites), STARLETTE, and similar retroreflector-bearing satellites measure plate motion, the Chandler wobble, and other geodynamic phenomena, and the retroreflector arrays the Apollo astronauts left on the Moon still bounce back laser beams shot from Earth. The lunar arrays have been used to test the theory of relativity.

During the last 30 or more years of his career, O'Keefe focused on the study of tektites, small glassy bodies of natural but unknown origin found in various "strewn fields" on Earth. In the 1950s and early 1960s, the leading theories were that tektites were of lunar origin, ejected by either impacts or volcanism, or they were formed by large asteroid impacts on Earth. O'Keefe published two books and many papers on the subject, and became convinced that tektites were ejected from volcanoes on the Moon.

However, since the late 1960s, scientists who have studied tektites have pointed to evidence that overwhelmingly suggests they were created as melt droplets from the impact of comets or small asteroids on Earth. O'Keefe's decades-long advocacy for a lunar origin saddened and sometimes angered many of his colleagues in the tektite community. On the program at his funeral, his family had included the words "Tektitae de luna sunt," which means "Tektites are from the Moon.

O'Keefe was endowed with a brilliant mind and a sharp wit. An innovative thinker, he possessed a conta-