MANFRED ROBERT SCHROEDER

1926–2009

Elected in 1979

"For founding the statistical theory of wave propagation in multi-mode media and contributions to speech coding and acoustics."

BY JAMES L. FLANAGAN

MANFRED ROBERT SCHROEDER, an internationally known acoustician, telecommunications research leader, and professor of physics, died on December 28, 2009, at his home in Goettingen, Germany. He was 83 years of age. His professional work is renowned for its diversity, embracing the fields of speech processing, room acoustics, computer art, and number theory.

In his youth his father, a mining engineer, and his mother encouraged an early interest in the beauty and utility of mathematics. He was a leading student in his secondary schooling, but still not above enjoying practical jokes on colleagues and friends. Like many science-oriented young people of the time, he was attracted to radio technology. He built short-wave receivers and transmitters and, despite government restrictions, surreptitiously listened to broadcasts from the BBC (British Broadcasting Corporation). He never considered himself a legitimate "radio amateur" ("ham") because of the difficulty of obtaining a government license and the (not unusual) additional obstacle of Morse code. But, in all other respects, he was a "ham."

Also, like many other youth of his time, Manfred's continued education was interrupted by the hostilities of World War II. At age 16 he was drafted into the German Air Force and

assigned to an antiaircraft unit, serving first in Poland and later in Holland. Because of his talent for electronics, he was trained in the early uses of radar for detecting range and direction. He therefore became part of an intensive technology race, an experience that no doubt contributed to his later remarkable zeal in telephony research.

After conclusion of hostilities, he returned to his home, rejoicing that it and his family were intact and unharmed during this turbulent time. He continued his education and entered the University of Goettingen. In due course, as his university studies advanced, he fell under the tutelage of Professor Erwin Meyer, director of the third physics institute and an internationally recognized authority in acoustics. Working toward a doctoral degree, Manfred conducted fundamental research on the distribution of acoustic normal modes in enclosures, relations that characterize the spatial spread of sound energy in structures such as rooms and auditoria. In 1954 he was awarded the Dr. rer. nat. (doctor of science) degree in mathematics and physics by the University of Goettingen.

His original work, and the laudation of his professors, drew the interest of the recruiting management of Bell Telephone Laboratories in the United States. Manfred was speedily offered, and accepted, employment in the research division of Bell Labs in Murray Hill, New Jersey. There, his research shifted toward telecommunications, and he devised unique designs for voice coders and for bandwidth conservation in speech transmission. Acoustics, of course, especially transducers, continued to play an important role in telecommunications. His technical successes were rapidly recognized, and he advanced into management responsibilities. In 1958, Manfred was appointed head of the acoustics research department, and later, in 1963, he advanced to director of the acoustics and speech research laboratory. Shortly, ultrasonics and mechanics research were topics added to his responsibilities. In the course of these technical activities in the United States, Manfred achieved two important personal conditions: In

New York he met and married his lovely wife, Anny, and he obtained American citizenship.

After compiling an impressive technical record at Bell Laboratories, replete with many internal and external publications, patents, and professional recognitions, Manfred received in 1969, and accepted, a prestigious offer from the University of Goettingen—namely, appointment as professor of physics and director of the Third Physics Institute. He then moved his home to Goettingen, but retained an affiliation with Bell Laboratories, and his home in Berkeley Heights, New Jersey. He consequently became a frequent flyer between Germany and the United States. In Goettingen he managed the institute, scheduled lectures, and supervised doctoral students working on theses in acoustics, many of whom found significant careers and recognition in industry and academia. In the United States he continued collaboration on speech coding for limited bandwidths and, in partnership with Bishnu Atal, expanded an extremely successful coding method based on linear prediction that is used for cell phone communications today.

Manfred retired from his Bell Labs affiliation in 1987, and from his professorship in Goettingen in 1991 and continued as institute director until 1994. He remained active as emeritus professor until his death and maintained an office at the university. His interests in communications, acoustics, and number theory never waned. For example, he added to his publication record a third book entitled *Computer Speech: Recognition, Compression, Synthesis* (Springer, 1999).

The array of major topics to which Manfred made fundamental contributions reflects his remarkable diversity in engineering and science. With colleagues Bishnu Atal and Suzanne Hanauer, he established a new technique for adaptive differential coding of speech by linear prediction, as aforementioned. The method is amenable to bandwidth compression over a range of about 1/2 to 1/16th of the traditional 64 kilobits/second digital telephone channel. In particular, the choice of 1/8 for derivative versions of linear predictive coding is now a design commonly used in

high-quality cell phone communications. An International Telecommunications Union standard has been formulated for the regimen of 8 kilobits/second voice coding.

Sound behavior in enclosures, an issue dear to Manfred's heart from his doctoral thesis days, led him to invent an advantageous practical method for measuring reverberation time by integrating the acoustic response of a room to a tone burst. His close familiarity with relationships between natural modes and frequency response, and his skill with computation, produced new methods for simulating the acoustic characteristics of enclosures, using rapidly emerging digital computers. These capabilities served him well when Manfred was asked to assist in diagnosing acoustic deficiencies in New York's Philharmonic Hall, a component of the city's Lincoln Center. With colleagues Bishnu Atal, Gerhard Sessler, and James West, he measured and characterized the problems and aided in formulating plans for improving the hall's acoustics. His use of frequency shifting to combat acoustic feedback in public address systems and his number-theoretic designs for sound diffusers (now known as Schroeder diffusers) represent other dimensions of his practical originality, contributing to the habitability of both concert halls and auditoria.

Constantly captivated by the beauty of mathematics, he stimulated early interest in abstract computer art, whereby versatile digital computers with sophisticated graphical output could reveal unique images of central relationships in equations. In fact, Manfred received awards from the arts community for his incomparable computer images.

As he progressed in his professorship, Manfred undertook prolific writing, producing scientific books on chaos, fractals, number theory, and computer processing of speech. His personal research produced more than 150 papers in archival journals, three books, and 45 U.S. patents.

Honors recognizing his ingenuity came to Manfred in a steady stream. Selected instances include election to seven different professional organizations: the Acoustical Society of America, the Audio Engineering Society, the American Academy of Arts and Sciences, the Institute of Electrical and

Electronics Engineers, the New York Academy of Science, the National Academy of Engineering, and the Goettingen Academy of Science. More concrete forms of honor included the gold medals of both the Acoustical Society of America and the Audio Engineering Society, the Helmholtz Medal of the German Acoustical Society, the Rayleigh Medal of the British Institute of Acoustics, the Medal of the International Speech Communication Association, and the Technology Prize of the Eduard Rhein Foundation.

Manfred's demeanor inevitably led to enjoyable engagement, whether on the knottiest technical problems, current events, or funny stories. His intellect, his devotion to mathematics and science, and his wit always made for a beneficial encounter. Communications research, his many colleagues, and his numerous students whose career paths he influenced will all share the deep sense of loss.

Manfred is survived by his wife Anny, in Germany and the United States; his daughter Marion in Bremen, Germany; his two sons, Julian in La Jolla, California, and Alexander in San Francisco; and his four grandchildren.