Emmett N. Leith

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EMMETT N. LEITH

1927–2005

Elected in 1982

"Contributions to holography and to the field of optical data processing."

BY KIM WINICK
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EMMETT NORMAN LEITH, Schlumberger Professor of Electrical Engineering and Computer Science at the University of Michigan, died December 23, 2005, at the age of 78.

Emmett was born in Detroit on March 12, 1927, and received his BS (1949), MS (1952), and PhD (1978) in physics from Wayne State University. He spent his entire 50-year career at the University of Michigan, where he supervised the research of 43 PhD students and regularly taught a variety of courses on basic optics and optical signal processing.

He was first employed as a research assistant (1952–56) and then promoted to a research associate (1956–60) at Willow Run Laboratories (WRL). In 1960 his research group at WRL was moved to the University of Michigan Institute of Science and Technology, where he became a research engineer. He was appointed an associate professor of electrical engineering in 1965 and promoted to full professor in 1968.

Emmett's seminal contributions to synthetic aperture radar (SAR), optical signal processing, and holography were made mostly during the 12-year period from 1952 to 1964. In 1951 Carl Wiley of the Goodyear Corporation had suggested that data collected from a small moving antenna could be used to synthesize a receiving antenna with a much larger effective aperture, thus increasing its spatial resolution. But because of

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the large amount of data collected from the SARs, neither data storage nor subsequent signal processing could be performed with the electronic equipment available at the time.

Following a discussion with Russel Varian, Louis Cutrona and Weston Vivian at WRL conceived the idea of the optical processing of SAR data stored on film. Beginning in 1954, Emmett worked with Cutrona and Vivian to investigate optical processing using incoherent light. In 1955 he and Leonard Porcello spent several months studying optical correlators for SAR processing based on both incoherent and coherent light. Between October 1955 and April 1956, Emmett recast the theory of a coherent optical correlator in terms of wavefront reconstruction, basically a holographic approach. He considered this his most significant work.

At the time he was working on radar, the material was classified, so the details did not begin to appear in the open literature until the mid-1960s. His holographic SAR theory, along with an analysis of the technique, appeared as an internal WRL memo dated May 22, 1956. Five months later, he became aware of earlier work by Dennis Gabor on wavefront reconstruction for use in electron microscopy, for which Gabor was later awarded the Nobel Prize (1971). Emmett described his reaction to discovering Gabor's work: "My feelings were mixed; there was some disappointment that the principles of wavefront reconstruction had already been invented, although in a wholly different context. This feeling was balanced with the knowledge that the concept of wavefront reconstruction was significant enough to have been published in the scientific literature."

Emmett's idea for SAR processing based on wavefront reconstruction had initially been met with indifference from the SAR community and had languished for about two years after it was developed. In 1957, WRL used optical processing to produce the first high-quality SAR images, and by 1959 Emmett's wavefront reconstruction formulation had become the dominant method of optical processing of SAR data.

Emmett subsequently suggested many important modifications to the basic optical processing scheme that led to major

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improvements in radar performance. These modifications included simultaneous pulse compression and beam sharpening and the introduction (with Adam Kozma and Norman Massey) of a tilted-plane optical processor. The processing of SAR data by optical means remained the mainstay of the radar community until well into the 1980s, when advances enabled electronic computing.

Gabor's concept of wavefront reconstruction had a number of serious deficiencies. In particular, it worked only for reconstructing transparencies, and even then the quality of the reconstruction was limited by the presence of overlapping twin images. Between 1956 and 1960, Emmett pondered the solution to the twin-image problem while he continued to work on SAR.

When Juris Upatnieks joined the Radar and Optics Group at the University of Michigan in 1960, he and Emmett began working together on the twin-image problem, which, based on their experience with SAR, they recognized as a problem of aliasing. They developed the off-axis approach to obviate the twin-image problem and explained their method in terms of communication theory—carrier amplitude modulation, frequency spectrum, side-band filtering, and the like. They demonstrated their off-axis technique by making high-quality holograms of grey-scale transparencies.

Late in 1963 Emmett and Upatnieks introduced the technique of diffuse illumination to demonstrate the first high-quality holograms of three-dimensional objects. In Emmett's words: "the availability of the laser…made possible the holography of solid reflecting objects with significant depth…. [This] resulted in high-quality imagery, with the images being fully three-dimensional, with full parallax, imagery of a sort never before seen, images that were, in an optical sense, a complete recreation of the original object distribution, complete with… all the other properties one sees in viewing a real-world object, but which are lost in conventional photography."[1] When they

[1] The evolution of information optics. *IEEE Journal of Selected Topics in Quantum Electronics* 6(6):1297–1304 (November–December 2000), p. 1299.

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presented their results publicly at the annual meeting of the Optical Society of America in the spring of 1964, they created quite a sensation.

Emmett Leith was elected to the National Academy of Engineering in 1982. In addition to this honor, he received many awards, including the National Medal of Science for Engineering (1979), IEEE Morris Liebmann Memorial Award (1968), Stuart Ballantine Medal of the Franklin Institute (1969), R.W. Wood Prize (1975) and Frederic Ives Medal of the Optical Society of America (1985), and Gold Medal of the SPIE (1990).

Emmett's work on SAR and holography had an enormous technical impact and was a major driving force in shaping the field of optical signal processing. In addition to his educational and scientific contributions, his work spurred many commercial applications that now constitute a multibillion-dollar industry. A humble individual by nature, he loved his work and remained active in his field until the time of his death.

He was survived by his wife June (née Neswold; she died September 9, 2012), their daughters Pam Wilder of San Jose and Kim Leith of Baltimore, and three grandchildren.

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