TINGYE LI

1931–2012

Elected in 1980

"Co-discovering the existence of low-loss electromagnetic-wave modes in open structures with application to laser resonators."

BY HERWIG KOGELNIK

TINGYE LI, an inspired visionary research leader in the fields of lasers and optical fiber telecommunications at Bell Labs and later at AT&T Research, died on December 27, 2012, at the age of 81.

Tingye was born in Nanjing, China, on July 7, 1931. As the son of a diplomat, he saw much of the world in his early youth, and his travels continued throughout his life. In recent years he traveled more than one gigameter to and from China.

He received a BSc degree in electrical engineering from the University of Witwatersrand, Johannesburg, South Africa, in 1953, and MS and PhD degrees in electrical engineering from Northwestern University in 1955 and 1958, respectively. He was also awarded an honorary doctor of engineering degree from National Chiao Tung University, Hsinchu, Taiwan, in 1991, and an honorary doctorate from the University of Witwatersrand in 2011.

He joined AT&T Bell Laboratories, in Holmdel, New Jersey, in 1957, where he did research in the fields of antennas, microwave propagation, lasers, and optical communications, and contributed more than 90 patents, papers, and book chapters in these fields.

He first worked on antenna research. One of his publications, which appeared in the July 1963 special Telstar issue of

the *Bell System Technical Journal*, deals with the radiation pattern of the famous horn antenna at the Bell Labs Crawford Hill Laboratory that is now a National Historic Landmark. It was designed and used for the world's first experiments in satellite communications, project Echo in 1960 and Telstar in 1962. This antenna was later used by Bell Labs radio astronomers Arno Penzias and Bob Wilson, who found the microwave background radiation originating from the Big Bang that created the universe and later received the Nobel Prize for this discovery.

Modern optical communications require lasers and optical fibers. Tingye got into lasers very early using the Huygens-Fresnel integral he had learned from antenna theory. He teamed with A.G. Fox and contributed a groundbreaking paper on laser resonators, starting research worldwide in the field of laser beams and resonators. Their paper, "Resonant Modes in a Maser Interferometer," appeared in the *Bell System Technical Journal* of March 1961; in 1979 it was named a Citation Classic. This pioneering work on laser resonator theory showed the existence of transverse laser resonator modes, provided for their understanding, and led to much further research. It showed that a laser beam bouncing back and forth between a pair of mirrors can resonate in a number of modes of energy distribution; each mode has a different characteristic phase velocity and diffraction loss per transit.

Tingye continued to write important papers in this field, including "Laser Beams and Resonators" (coauthored with this author), published in *Applied Optics* in October 1966. The article was noted in the journal's 50th anniversary issue as the second most cited paper in its history.

As a result of their pioneering work, Fox and Li received the 1979 IEEE David Sarnoff Award, "For the discovery of modes in open structures and their applications to laser resonators," and in 1980 he was elected to the National Academy of Engineering. He was also elected to the Chinese Academy of Engineering and to the Academia Sinica.

In 1967 Li was appointed head of the Repeater Techniques Research Department at the Crawford Hill Laboratory, with

responsibility for research on optoelectronic devices and signal regenerators for optical communication. Soon after the early low-loss fibers and continuously operating semiconductor junction lasers were announced, Tingye and his department succeeded with an experimental demonstration of a prototype optical repeater for a fiber optic transmission system operating at 6.3 Mb/second. In 1972 he presented these results at Crawford Hill to top AT&T executives and the results were documented in the *Bell Laboratories Record* of May 1973. This milestone accomplishment was an important factor in the AT&T decision to consider optical fiber transmission, and led to the Chicago Project of 1977, in which AT&T installed 1½ miles of fiber in the city's public network and transmitted messages at a bit rate of 44.7 Mb/second.

From 1976 to 1984 Li led the Transmission and Circuit Research Department and, briefly, the Lightwave Media Research Department, concerned with research on transmission media and circuitry for optical fiber systems. From 1984 to 1996 he headed the Lightwave Systems Research Department, in charge of research on high-speed techniques and high-capacity systems for lightwave transmission and networking. In these capacities he and his department were deeply involved in the research that led to the worldwide commercial application of optical fiber communications and to the exponential growth of the capabilities of lightwave systems: the capacity per fiber increased by approximately a factor of 100 every ten years, from the 6.3 Mb/second of the early research system to research demonstrations exceeding 100 terabits/second. Commercial deployment of advanced systems was generally five to seven years behind the laboratory demonstrations. Key innovations that enabled these advances included single-mode fibers, single-frequency lasers, erbium-doped fiber amplifiers, and wavelength-division multiplexing (WDM). Details of these advances are reported in Li's article "The Impact of Optical Amplifiers on Long-Distance Lightwave Telecommunications" in the November 1993 *Proceedings of the IEEE*.

During this time of rapid worldwide technological advances, Tingye's Systems Research Department was recognized as a

world leader in high-speed single-channel fiber transmission. He and his colleagues did early work on WDM systems, testing and selecting the best technology components with the final goal of a practical systems demonstration. Their success stimulated a field trial by AT&T at its Roaring Creek Facility (Pennsylvania) that was also very successful. The trial was published by Jonathan A. Nagel and colleagues at the Optical Society of America (OSA) Topical Meeting in 1992, describing their use of optical amplifiers and four WDM channels operating at 1.7 Gb/s each.

Another of their milestone accomplishments was documented in an article by Andrew R. Chraplyvy and colleagues entitled "8*10 Gb/s Transmission through 280 km of Dispersion-Managed Fiber" in the *IEEE Photonics Technology Letters* of October 1993. Then came the breaking of the one-terabit-barrier announced at the Optical Fiber Communications Conference of 1996 in a presentation by Alan H. Gnauck and colleagues titled "One Terabit/s Transmission Experiment."

In 1996 Li was appointed manager of AT&T's Communication Infrastructure Research Laboratory. He retired in 1998 and worked as a consultant, including for several startup companies.

Tingye Li was admirably active in the worldwide research community in lasers and optical fiber communications. He was a member of the program committee of the first conference on optical fiber communication (OFC) held in Williamsburg in 1975; in 1982 he chaired the program committee and in 1984 the conference. In addition, he was a program committee cochair and general cochair of the Conferences on Lasers and Electro-Optics (CLEO).

He was a fellow of the OSA, the Institute of Electrical and Electronics Engineers (IEEE), and the American Association for the Advancement of Science. His professional society activities included chairing the Photonics Division of the OSA Technical Council and the OSA International Activities Committee; he was also a member of the board of governors and chair of the awards committee of the IEEE Lasers and

Electro-Optics Society. He was elected OSA vice president in 1993 and president in 1995.

He was a member of the editorial boards of the *Proceedings of the IEEE* and *Microwave and Optical Technology Letters*, associate editor and topical editor of *Optics Letters*, associate editor of the *Journal of Fiber and Integrated Optics* and *IEEE/OSA Journal of Lightwave Technology*, and guest editor of a special issue of the *IEEE Journal of Quantum Electronics* on devices for optical fiber communications. He edited a book series on *Optical Fiber Telecommunications* that has served for three decades as the comprehensive primary resource covering progress in the science and technology of optical fiber telecom. It is an essential for the bookshelves of scientists and engineers active in the field.

Li's highly successful leadership in optical fiber communication was recognized by a string of awards, including the 1995 OSA/IEEE John Tyndall Award for "sustained advances in high-capacity optical fiber communication systems created by his pioneering research, leadership, and personal contributions over more than two decades"; the 1997 Frederic Ives Medal, OSA's highest award, recognizing overall distinction in optics; the 2004 IEEE Photonics Award for "leadership, vision, and pioneering contributions in the field of optical fiber communications and laser science"; and the 2009 Edison Medal for "leadership, vision and pioneering contributions in the field of broadband optical fiber communications."

As a research leader, Tingye attracted great talent to his department at Bell Labs. He used to say "I hire only people who are smarter than I am"; indeed, several former members of his department are now members of the NAE. He had unusual wisdom, great insights, and was an outstanding and encouraging mentor of younger generations. At Bell Labs in Crawford Hill he did many things that enhanced the intellectual level for all of us (for example, he considerably improved this author's writing in English). He also made sure that we understood that China invented almost everything, including paper, printing, gun powder, and the compass. And he taught us quite a bit about Kung Fu-Tsu and his sayings, one of which

is a perfect description of Tingye: "The superior man is modest in his speech, but exceeds in his actions."

Tingye's family was a great source of pride for him. He had met his future wife Edith Wu at Northwestern University and told his friends "I wooed Wu and won Wu." They married in 1956 and had two daughters, Debbie and Kathy. Kathy writes:

> Dad, or "Gung Gung" to his grandchildren, was someone who not only taught us valuable lessons in life but also showed us how to live. From his skiing adventures to his "China 101" educational trips with his daughters and their families, to his globe-trotting trips with Mom, he always enjoyed to the fullest, wherever he went. Every Christmas he spent in Snowbird, Utah, one of his favorite places. We celebrated Christmas, Chanukah, family, and great skiing. In the early years, he would often stay inside to play with [grandchildren] Jessi and Michael. Later, he took them down Chickadee and Big Emma, the beginner runs. And later, he was so proud of their skiing as they became athletic, expert skiers. But almost every night, we'd sit down for dinner, three generations, at the same table and talk about our day on the slopes.

Debbie concludes:

> So much of what my father embodied can be described in one word: passion. He lived his life with passion—a joie de vivre. And this approach to life he passed on to his children and grandchildren. Our family grabbed at the opportunity to move to London because Gung Gung had lived all over the world and had told us so many exciting stories. [Grandchildren] Jay and Scott have found careers that combine their strengths and their passions. Skiing, photography, poetry, travel, and a love for Chinese art and oriental rugs—all are in our lives because of him.
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> My father sometimes lamented the fact that the Li family name would not be continued in future generations as he only had daughters and nieces. However, he did not realize that the legacy of Tingye Li would truly live on forever in the countless stories, memories, and pearls of wisdom his family, friends, and colleagues cherish and will continue to pass on for many years to come.