individual talents and interests to the best of their ability.

Away from science, Debbie was a warm and dedicated mother. She also played violin and ukulele; enjoyed camping, skiing, and other outdoor activities; and was an effective utility player for the JILA softball team. She touched thousands of people in and out of science who will miss her terribly.

John Bohn
JILA
Boulder, Colorado

John Michael Julius Madey

The inventor of the free-electron laser (FEL), John Michael Julius Madey, died of lung cancer on 5 July 2016 in Honolulu, Hawaii. He left an indelible mark on the international accelerator community.

John was born in Elizabeth, New Jersey, on 28 February 1943. In 1946 he and his family moved to a new house in Clark, where John grew up. His father owned an auto repair shop and instructed him and his older brother Jules in basic machine-shop skills. When John was 11, he and Jules studied together for their ham radio licenses from the Federal Communications Commission and provided morale communications for US Navy crewmen and civilian scientists stationed in Antarctica and their loved ones back home.

John's increasing fascination with the vacuum tubes used in the transmitters led him to learn everything there was to know about vacuum-tube technology. He was an avid builder of his own ham equipment, and the skills he developed served him well in his physics career. Howard Schrader, the brother of John's next-door neighbor, owned one of the largest collections of vacuum tubes in the world. After hearing about the Madey brothers' enthusiasm for the technology, Schrader, who was Princeton University's official photographer, introduced them to John Wheeler and other faculty members.

In 1960 John went to Caltech, where he received a BS in physics in 1964 and an MS in quantum electronics in 1965. While there he became deeply interested in whether the transition rate for bremsstrahlung could be amplified through stimulated emission. That curiosity continued when he went to Stanford University, where he earned a PhD in 1970 under the supervision of William Fairbank and conceived his most important invention: the FEL. Its bunched electron beam would pass through a periodic magnetic structure to stimulate the emission of light. In 1976, while working at Stanford's High Energy Physics Laboratory, John and his team succeeded in demonstrating the FEL principle; they used a 24 MeV electron beam and a 5-meter-long wiggler magnet to amplify the beam from a carbon dioxide laser. By 1978 they had added mirrors to the system and increased the electron energy to 43 MeV, which allowed laser oscillations at a wavelength of 3.5 μm in the near-IR part of the optical spectrum. The power and efficiency were small—300 mW and 0.01%, respectively—but it was clear that the FEL scheme worked.

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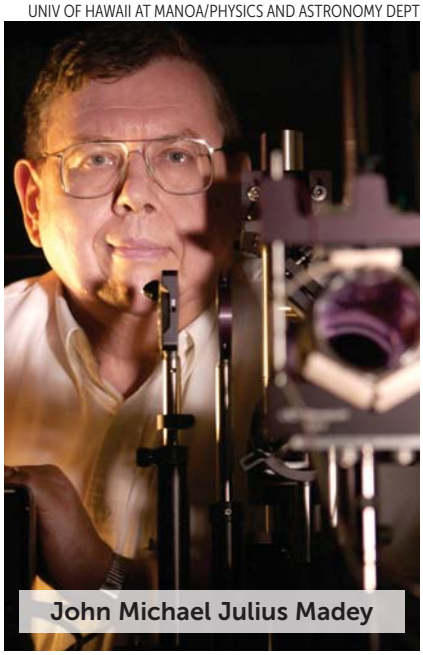

John Michael Julius Madey

In contrast to early FELs that used mirrors or optical cavities, today's linac-based FELs, including SLAC's Linac Coherent Light Source and the European XFEL, operate at much shorter wavelengths. They have proved indispensable for research in physics, chemistry, and biology because their highly intense, coherent electromagnetic radiation is tunable over a broad range of frequencies.

In 1986 while still at Stanford, John became a professor of electrical engineering. Two years later he joined Duke University's physics department, and the following year he transported his FEL research laboratory there from Stanford and continued to direct it for almost 10 years. John moved to the department of physics and astronomy at the University of Hawaii at Manoa in 1998 and built an FEL facility from scratch using some parts obtained from Duke. The facility provided a unique opportunity for hands-on training of graduate students in FEL science and technologies. John was a great mentor; working side by side with students, he imparted his knowledge and expertise.

John held 13 patents on FEL-related technological inventions. A legal dispute over some of his patents led to a judgment in John's favor. On 3 October 2002, in *Madey v. Duke University*, the Federal Circuit Court of Appeals ruled that the university was infringing on two of John's patents because it was profiting from them beyond the experimental use "solely for amusement, to satisfy idle curiosity, or for strictly philosophical inquiry." The historic case, which ended a 170-year-old practice in which scientists freely used patented technologies when working on basic research that had no commercial application, has been discussed and written about by many legal scholars around the world.

Among the numerous awards and international recognitions that John received was the American Physical Society's 2012 Robert R. Wilson Prize for Achievement in the Physics of Particle Accelerators. At the 2015 Nobel Symposium on Free-Electron Laser Research in Sigtuna, Sweden, he served as the keynote speaker.

John will be remembered by his colleagues as the enthusiastic developer of the FEL and a prolific scientist of great drive and insight.

Pui Lam
University of Hawaii at Manoa
Honolulu
Vladimir Shiltsev
Fermi National Accelerator Laboratory
Batavia, Illinois
Frank Zimmermann
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