Obituary | Logan E. Hargrove | *1935–2019*

Logan E. Hargrove, a longtime supporter of acoustics, especially physical acoustics, performed his own important research and also had a wide impact in the scientific careers of others and the Acoustical Society of America (ASA). He passed away on February 18, 2019.

After receiving his PhD in physics from Michigan State University (East Lansing) in 1961, the first stage in Logan's career was at Bell Laboratories, where he invented the mode-locked laser. Much like the acoustic longitudinal modes of a long pipe, the longitudinal optical modes of a long laser cavity are nearly harmonically spaced, with a frequency spacing equal to the inverse of the round-trip time of light along the cavity. A tube of energized helium-neon inserted in the optical cavity provided gain to many of these modes, which, in general, would be excited at random amplitudes and phases. Logan's invention was to also insert a glass block attached to a quartz ultrasonic transducer into the optical path. By setting up a 28-MHz acoustic standing wave in the glass transverse to the light, he could periodically modulate some of the optical beam away from the optical axis twice per cycle at 56 MHz, the inverse of the optical round-trip time, because the glass block became an optical diffraction grating on the positive or negative density fluctuations of the glass. He discovered that beyond a certain threshold of sound amplitude, the speeds of individual optical modes would adjust to lock their phase onto high multiples of the 56-MHz modulation. When a large number of these modes phase lock together, their Fourier superposition is a very short, very intense pulse of light bouncing back and forth along the laser cavity. Others refined the technique to generate pulses of femtosecond lengths.

So if you hear about mode-locked femtosecond lasers being used in fast chemical reaction experiments, pump-probe measurements in semiconductors, two-photon microscopes, or bladeless LASIK eye surgery, a significant piece of that is due to Logan. The GPS system and the fundamental definition of the unit of time rely on atomic clocks that use a stabilized frequency comb (work that received the 2005 Nobel Prize in Physics), which relies on mode-locked lasers. Logan's invention of the mode-locked laser, at 29 years of age, is still important.

After 13 years, Logan left Bell Laboratories to join the Office of Naval Research as a deputy director of the physics division and program officer because he felt he could have more impact on science by supporting and influencing the work of others. There, he sponsored work in fields such as nonlinear acoustics, the unusual acoustic modes of superfluid helium, resonant ultrasound spectroscopy for measuring the mechanical properties of exotic materials, and thermoacoustic heat engines.

Logan was a driving force behind the creation in 1992 of the ASA Physical Acoustics Summer School, which brings together otherwise isolated graduate students in a week-long immersion into wide aspects of their field. He served on multiple ASA committees. He received the 1970 ASA Biennial Award for contributions to acoustics and was a Fellow of ASA and the American Physical Society. Logan is survived by two sons, three grandsons, and two daughters-in-law.

Selected Publications by Logan E. Hargrove

Hargrove, L. E. (1960). Fourier series for the finite amplitude sound waveform in a dissipationless medium. *The Journal of the Acoustical Society of America* 32(4), 511-512.

Hargrove, L. E. (1968). *Mode Locking in a Synchronously Modulated Maser.* US Patent No. 3,412,251, November 19, 1968.

Hargrove, L. E., and Thurston, G. B. (1957). Optical method for analysis of fluid motion. *The Journal of the Acoustical Society of America* 29(8), 966-968.

Thurston, G. B., Hargrove, L. E., and Cook, B. D. (1957). Nonlinear properties of circular orifices. *The Journal of the Acoustical Society of America* 29(9), 992-1001.

Written by:

Joe Dickey

Email: joe@joedickey.com

3960 Birdsville Road, Davidsonville, MD

Robert M. Keolian

Email: keolian@psu.edu

Sonic Joule LLC, State College, PA