

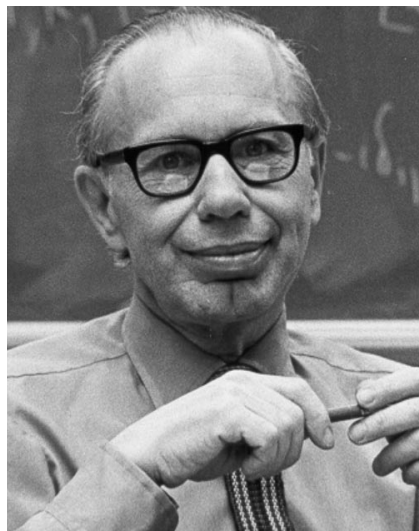
name; Les later added his middle name, unaware of its more common spellings. He attended the Case School of Applied Science (which later was named the Case Institute of Technology, the forerunner, with Western Reserve University, of Case Western Reserve University), where he received his BS in physics in 1941. He took one year of graduate study at the University of Wisconsin–Madison with Leon Brillouin, and was awarded a physics master of philosophy degree in 1942.

That same year, Les joined Columbia University's Underwater Sound Laboratory, where he participated in research associated with the war effort. It was there that he published, in 1945, his first, and perhaps most influential, paper on the behavior of waves in the presence of a disordered array of scatterers. Originally developed to treat the multiple scattering of sound from the cloud of cavitation bubbles in the wake of a submarine, this theory was found to have a wide application in areas as diverse as neutron scattering and the behavior of electrons in disordered alloys. Les's fundamental insights were subsequently rediscovered many times by later workers who were unaware of his paper.

His time at Columbia was eventful, and is especially poignant now in light of the World Trade Center airplane disasters on 11 September 2001. Working one Saturday on the 64th floor of the Empire State Building, he was startled to hear the sound of a rapidly approaching airplane. A tremendous noise signaled that it had crashed into the building a few floors above him, resulting in some loss of life. Considerate, but also sparing with his words, Les sent a telegram to his wife, Roma, in Florida with this simple message: "Don't worry. I'm all right!" She was unaware of the accident and, on receiving his telegram, worried!

In 1945, Les went to the University of California, Berkeley, to pursue his PhD in physics in the group of J. Robert Oppenheimer. After two years there, during which he also worked with Luis Alvarez and David Bohm, he followed Oppenheimer to the Institute for Advanced Study in Princeton, New Jersey, where he completed his doctoral degree in 1948. Les then returned to the Case Institute of Technology as an assistant professor of physics.

The paper for which Les is most widely recognized arose from a collaboration with another former student of Oppenheimer, Dutch physicist



LESLIE LAWRENCE FOLDY

Siegfried Wouthuysen. During the summer of 1949 at the University of Rochester, where they worked with Robert Marshak, Les and Wouthuysen wrote a preprint on the nonrelativistic limit of the Dirac equation. At a summer school in Michigan, a French physicist vigorously criticized this work, claiming to have found an error in it. This criticism stimulated Les and Wouthuysen to reformulate their calculation in such a completely clear and elegant way that all objections crumbled. The approach they adopted was to make use of a canonical transformation that has now come to be known as the Foldy–Wouthuysen transformation. Before their work, there was some difficulty in understanding and gathering all the interaction terms of a given order, such as those for a Dirac particle immersed in an external electromagnetic field. With their procedure, the physical interpretation of the terms was clear, and it became possible to apply their work in a systematic way to a number of problems that had previously defied solution.

Les's work in the four decades that followed covered an extraordinarily rich variety of topics, ranging over particle, nuclear, many-body, atomic, and solid-state physics, as well as acoustics, and scattering and accelerator theory. With Fred Milford, he developed, in 1950, the theory of nuclear magnetic moments in distorted nuclei. He was also the first (1952) to realize that the magnetic field of the neutron had to be considered in the theory of electron–neutron scattering; this realization led to what is now called the Foldy term. This idea came to him while he was brushing his teeth one night; he developed the

formalism and sent off his paper to the *Physical Review* the very next day! On another occasion, in 1954, he gave a proof that there could exist no charged particle lighter than the electron, because if there had been such particles, they would have modified the Lamb shift.

Les was revered by his students and colleagues for more than his intellectual gifts. His gentle modesty concealed a firm core of moral principle that led him to refuse government support for his research during the Vietnam War. When four students were killed by the Ohio National Guard at the nearby campus of Kent State University, Les was an influential voice in his university's decision to suspend classes.

Les will be most remembered for the generosity he showed in sharing his knowledge, insight, and wisdom to all who sought his advice. If one approached Les for scientific help because of his reputation as a fount of wisdom (and he indeed was so besieged by students and senior faculty alike), then one stayed because of his kindness. For a celebration of Les's 80th birthday, Case Western Reserve University physics department received hundreds of enthusiastic letters and e-mail messages from well-wishers; the outpouring of affection and admiration was stunning. His death, coming so soon after this celebration of his life, will not diminish the memory of his impressive scientific achievements and his unique goodheartedness.

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Howard Thomas Powell

Howard Thomas Powell, a noted laser physicist and contributor to the inertial confinement fusion (ICF) program at Lawrence Livermore National Laboratory (LLNL), died suddenly of an apparent heart attack on 15 November 2000 while attending to laboratory business in Washington, DC. A leader in the development of high-power gas and solid-state laser systems for almost three decades, Howard was internationally renowned for his contributions.

Howard came from humble beginnings. Born on 2 October 1944, he was reared in Woodland, a small logging town in Washington State. The son of

a logger, he graduated from Caltech in 1966 with a BS in physics. He received his PhD in applied physics from Cornell University in 1971 under George J. Wolgal. His thesis topic was "Inhomogeneous Saturation and Self-Pulsing in the CO₂ Laser."

Howard continued postdoctoral research at Cornell before going, in late 1971, to the McDonnell Douglas Research Laboratories in St. Louis, Missouri, as a research physicist. In 1973, Howard joined LLNL as a staff scientist in the laser division; there, he made several major contributions to gas lasers. In 1974, Howard and his colleagues reported lasing in the green from the transient diatomic molecule xenon oxide and demonstrated lasing on the auroral transition of oxygen in electron beam-pumped mixtures of krypton and oxygen. Stimulated emission on the auroral and transauroral lines in selenium was reported in 1978 and lasing of atomic sulfur was realized in 1979. This seminal work on excimer molecular lasers paved the way for subsequent research on diatomic excimer molecules and the rare gas-halide lasers, in particular, that are now used worldwide in applications such as photolithography, medical procedures, and materials processing. In 1976, Howard codiscovered the krypton chloride ultraviolet excimer laser and was an early leader in exploring the feasibility of the krypton fluoride laser as a driver for ICF.

Throughout the 1980s and 1990s, he was a pioneer in the development of solid-state lasers, particularly in flashlamp pumped neodymium:glass amplifiers for ICF. In 1988, he led the Precision Nova campaign, which laid the groundwork for establishing LLNL's readiness to begin work on the National Ignition Facility. Adopting the pioneering work by scientists in Japan and the US, Howard also led the deployment of beam smoothing on the Nova laser—a feature now recognized as essential for all approaches to laser-driven ICF. In 1994, Howard founded and led LLNL's laser science and technology program, which achieved many successes, including the first demonstration of a petawatt laser, development of high-average-power femtosecond lasers and repetitively pulsed diode-pumped lasers, demonstration of laser-generated neutrons, and development of large-aperture diffractive optics.

In addition to his numerous scientific achievements, Howard inspired young scientists and engineers, and was an unusually effective mentor known for his integrity and passion



HOWARD THOMAS POWELL

for science. He particularly loved to bring science to young people by visiting his local high school as a guest speaker. He attracted a considerable number of scientists to LLNL and set an example that engendered trust and devotion.

In addition to being a distinguished man of science, Howard had a deep appreciation of art. He had a particular fondness for American history and was an avid collector of early American furniture and glassware. He was also an aspiring vintner; he and his wife enjoyed growing grapes and producing wine. Howard was deeply involved in his Livermore, California, community both as a soccer coach for many years and as a long-time member of the Livermore Valley Tennis Club. He also loved the outdoors and spent many happy vacations in wilderness areas around the country.

Howard has left an indelible mark on laser science and technology, ICF, and LLNL. Beyond his scientific and technical accomplishments, he was widely respected and admired for his affable personality, his mentoring of young scientists, and his friendship to all he encountered. He will be sorely missed by his surviving family, his staff at LLNL, and his numerous colleagues in the international community who were the beneficiaries of his scientific acumen and warm personality.

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