IN MEMORIAM

Charles Hard Townes
Professor of Physics, Emeritus
UC Berkeley
1915 – 2015

Charles Hard Townes, co- inventor of the maser and laser, and famous for his research in microwave spectroscopy and in microwave and infrared astronomy, died peacefully on January 27, 2015, in Oakland, California, at the age of 99. He was born on July 28, 1915, in Greenville, South Carolina, the fourth of six children of Henry Townes, a small town lawyer, and Ellen Hard. After graduating from the local college, Furman University, he obtained a masters degree in physics at Duke, and then applied to Caltech. Despite being turned down, he took a train to Pasadena to see if he could persuade the faculty to accept him. He showed them that he had solved all of the problems in the textbook by W. R. Smythe, which had notoriously difficult problems. He was eventually accepted at Caltech, and he did his Ph.D. research under Smythe in 1937-39 on the separation of isotopes and on the determination of their nuclear spins. In 1939 he began research at Bell Labs in New York. While there he met and married his beloved wife and partner of 74 years, Frances Brown, and together they raised four daughters, Linda, Ellen, Carla and Holly.

During World War II Charlie developed expertise in microwave technology, especially in the development of 1.25 cm radar. After the war, initially at Bell Labs, and later in 1948, as Associate Professor at Columbia University, he explored the properties of molecules with high- resolution cm- wave spectroscopy. During the period 1951-53 he and his colleagues conceived and named the maser, the first device to use stimulated emission for signal amplification, in this case microwaves.

His research culminated in his important 1955 textbook Microwave Spectroscopy, with his brother- in- law, Arthur Schawlow. In 1957 he and Schawlow showed theoretically that the principle of the maser could be extended into the infrared and optical domains. From 1959 to 1961 he was on leave from Columbia serving as vice- president and director of research at the Institute of Defense Analysis in Washington, D. C. He was Professor of Physics and Provost at Massachusetts Institute of Technology from 1961 to 1966, when he was named Institute Professor.

For his work on the maser and laser concepts, Townes shared the 1964 Nobel Prize in Physics with N. G. Basov and A. M. Prokhorov of the Lebedev Institute. The citation read: "for fundamental work in the field of quantum electronics which has led to the construction of oscillators and amplifiers based on the maser- laser principle."

In 1967, during Berkeley's Free Speech Movement, University of California President Clark Kerr learned that he was considering leaving MIT. He offered Charlie Townes a very prestigious position with the title "Professor of the Graduate School at Berkeley". The Physics Department provided him generous space on the fifth floor of the then recently constructed Birge Hall, with a mix of offices and labs adjacent to the Campanile and with a magnificent view of the San Francisco Bay and the Golden Gate Bridge.

Charlie and his colleague Jack Welch in the Astronomy Department started the explosion of activity in interstellar molecular spectroscopy in the late 1960s by detecting NH3 and H2O in interstellar space (remarkably with H2O acting as a natural maser), demonstrating that interstellar clouds were much denser than previously known. As a result, many species of molecules are able to form, shielded from photodissociation by stellar UV light. We now know that the presence of dust and molecules is critical for the formation of stars, as they can cool interstellar gas to low temperature, when gravity can overcome thermal motions.

Another important highlight of Charlie's Berkeley astronomy research was the detection of very rapidly moving ionized gas clouds at the Center of our Galaxy. This work provided the first evidence for a concentration of mass there of about four million times the mass of the Sun. By 1982 Charlie and his group were fairly certain that this object was a supermassive black hole, whose existence in galactic nuclei had been proposed by Lynden- Bell and Rees, following the discovery of the quasars. Detailed studies of orbiting stars with ever better resolution and precision have since fully confirmed and strengthened Charlie's conclusion.

Another example of those remarkable Berkeley astrophysics years was the development of infrared spatial interferometry, ISI, which kept Charlie busy throughout this last phase of his career. Extrapolating radio interferometry techniques to a wavelength of 10 μm, 10,000 times smaller than classical radio waves, and replacing electronic oscillators by CO2 lasers, Charlie used this novel technique to resolve and map the infrared emission from dusty stars with a level of detail far surpassing that possible even with the largest ground- based telescopes. Walt Fitelson, the principal assistant of Townes, helped set up offices and lab space in a small Annex. Later, state congressman John Garamendi provided funding for a large new building that doubled the capacity of SSL. Garamendi's plan was to use the additional income to be generated by projects housed in the new building to offset the construction costs. Bob Weitzmann, an engineer at SSL, helped Charlie with the initial planning for an Infrared Spatial Interferometer (ISI) that had been conceived by Charlie. After Weitzmann retired and moved to Florida, Charlie hired a new engineer, Ed Wishnow, to help with the design and construction of three large movable telescopes for interferometry with ISI. Wishnow et al. (1999) designed a novel far- infrared system to measure weak absorption spectra of gases at pressures up to a few atmospheres and at temperatures as low as 20 K. Its principal component was a multiple reflection mirror cell, cooled either with liquid nitrogen or with the boil- off gas from liquid helium. This huge cell, of volume 35 liters, has an f/10 optical beam and a pathlength that can be varied from 4 to 60 m. At the longest pathlength, diffraction limits the lowest usable frequency to 20 cm-1. The cell was designed to be coupled to a Fourier transform spectrometer and a 1.6 K bolometer.

This project consumed the last 30 years of Charlie's life. With ISI he and his students and his colleague Ed Wishnow were able to track changes in the size of the red supergiant star Betelgeuse over an 18 year period (Townes et al., 2009; Ravi et al.; Lockwood et al. 2014).

Charlie was truly a superb experimentalist, and he and Wishnow, with the help of a generation of Berkeley students and post- docs, created the ISI telescope. It is extremely rare that such a novel and ambitious instrument was able to be developed by graduate students and faculty entirely in a university setting rather than by an industrial firm.
Charlie had another important attribute: a superb ability to take on important tasks for the U. S. government and to form and lead boards and committees. One was the Apollo program to send astronauts to the moon. When someone in U. S. government would ask his advice as to how to deal with a problem of national importance, Townes would suggest that a high- level committee should be formed. Almost always Charlie would then be asked if he might be willing to agree to create the committee and chair it.

After the Russians launched Sputnik in 1957, Charlie felt an obligation to help his country, when called upon, with scientific and technical advice. He agreed to spend 1969-1971 in Washington as Vice President of the Institute for Defense Analysis. There he founded and later served on the JASON advisory group, a secret committee that has been advising our government for many years on matters of military importance during its summer retreats. Over the years Charlie had many important and influential roles as a government advisor. To name a few, he was a member on the Apollo- Program Advisory Committee to NASA, as well as a member of the Science Advisory Committee to four U. S. Presidents. In the early 1980s he chaired the MX Missile Basing Committee under President Reagan.

Charlie and his wife joined the First Congregational Church when they came to Berkeley, which played an important part in their lives. Charlie was a Christian who was often asked to speak about how he rationalized

Christianity and science. To his great surprise, the Templeton Foundation awarded him a million dollar prize on the basis of his talks on his beliefs and his rationalization of religion and science. He was awarded many honorary degrees, and for a while stopped accepting them. Only when a former student or close friend begged him to accept another honorary degree on the grounds that it would help his career or his university did Charlie agree.

In addition to his numerous honorary science degrees, three U. S. universities have named new science centers in his honor. In October 2008 Furman University in Greenville, South Carolina dedicated its $62.5 million facility as The Charles H. Townes Center for Science, and a reading room named for his wife Frances. The Charles H. Townes Laboratories for Optical Science and Technology at Clemson University in Clemson, South Carolina was dedicated in 2008. The Townes Laser Institute at the University of Central Florida's College of Optics and Photonics in Orlando was dedicated in May 2007. Charlie served on the Pontifical Academy of Sciences, which advises the Pope. Not all Popes have asked him and the Academy for their advice, however.

To learn more about the lives of Charlie and Frances, read their books "How the Laser Happened: Adventures of a Scientist" by Charlie, and "Misadventures of a Scientist's Wife" by Frances.

P. Buford Price