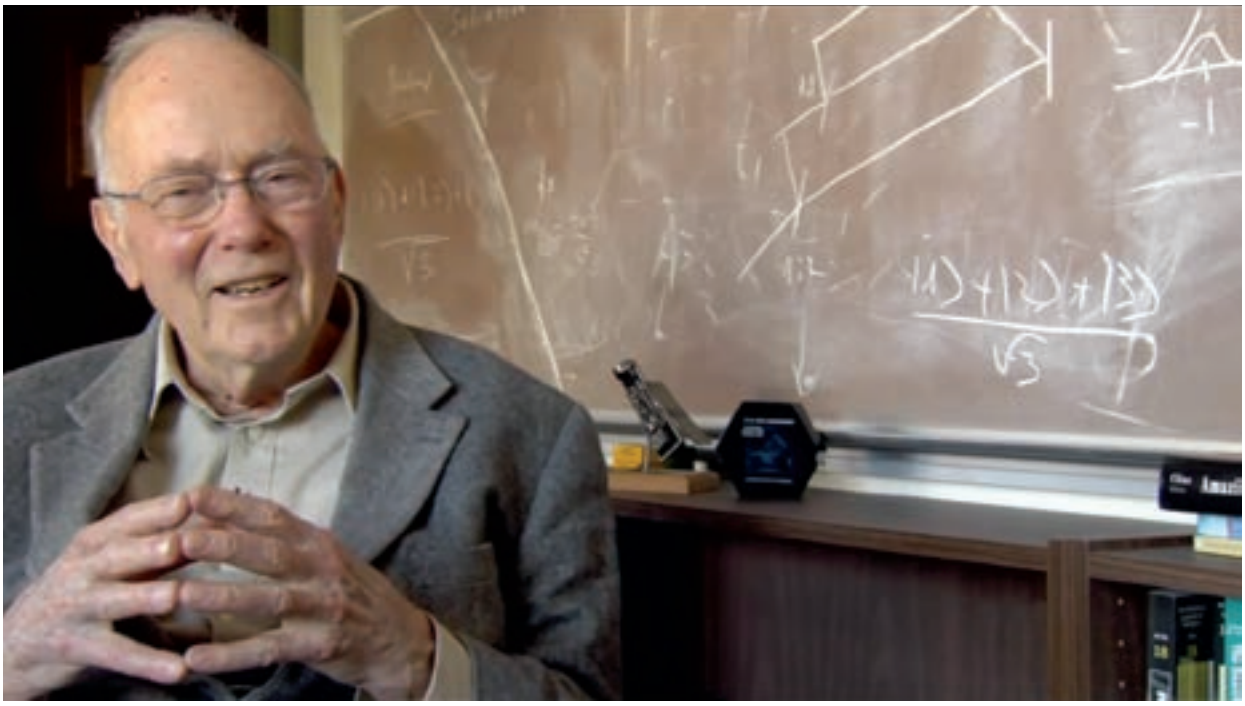

Charles Hard Townes

The Second Half-Century

PATRICIA DAUKANTAS

After receiving his 1964 Nobel Prize for maser and laser physics, this OSA Honorary Member pursued his diverse interests in basic scientific research, advised the U.S. government on aerospace and defense issues and pondered deep questions about science and religion.

Facing page: Charles H. Townes, with wife Frances H. (Brown) Townes, receives the 2005 Templeton Prize at Buckingham Palace, U.K. (Courtesy of Clifford Shirley/Templeton Prize). Above: Townes during an interview for the South Carolina Hall of Fame (Courtesy of the S.C. Hall of Fame, USA).

Early one evening in 2008, a visitor to the Mount Wilson Observatory in Southern California (USA) might have seen a tall, white-haired man using a carbon-dioxide jet to blow dust off the surface of a telescope mirror in preparation for a night of studying the stars. The gentleman wasn't an aging observatory technician, though. He was a Nobel laureate who had revolutionized much of 20th-century science and technology.

Charles Hard Townes, who died in January of this year—six months short of his 100th birthday—lived another 50 years after winning the 1964 Nobel Prize for maser and laser physics. However, this OSA Honorary Member had interests extending beyond optics and photonics; he described himself in his U.S. National Academy of Sciences profile as an astrophysicist and also wrote articles and gave speeches on the similarities of science and religion.

Townes brought his formidable intellect and insatiable curiosity to a diverse range of scientific and societal questions.

Townes brought his formidable intellect and insatiable curiosity to a diverse range of scientific and societal questions. He and his graduate students built the first mid-infrared astronomical interferometer—a significant feat in itself—and discovered that molecules of more than two atoms existed in interstellar space. He contributed to the U.S. Apollo moon-landing program in the 1960s, studied nuclear-missile issues in the 1970s and served on a Hubble Space Telescope review panel in the early 2000s.

All the while, Townes watched his laser idea grow from a "solution looking for a problem" to a foundational technology in modern life. Despite his busy work and travel schedule, he maintained close family ties, attended church regularly and pursued at least one hobby that had nothing to do with physics. To celebrate his long life, *Optics & Photonics News* takes a look at some of his lesser-known achievements.

Midlife: Provost of MIT

At the time of his 50th birthday in 1965, Townes was serving as provost and professor of physics at the Massachusetts Institute of Technology (MIT, USA). He had arrived there in 1961 after a brief stint at the Institute for Defense Analyses, a think tank in Washington, D.C.

During his tenure at MIT, Townes took two doctoral students: Raymond Chiao (now a University of California Merced professor who studies quantum optics) and Elsa Garmire, (now a nonlinear-optics specialist at Dartmouth College, USA, she served as OSA President in 1993). He supervised a few postdoctoral fellows and spent a year collaborating with Boris Stoicheff (OSA President in 1976), who was on leave from the University of Toronto in Canada. He also invited his former Columbia University (USA) student Ali Javan, co-inventor of the gas laser, to join the MIT physics department, and they did some, in Townes' words, "moderately important" work in the new field of nonlinear optics.

During the 1960s, with the encouragement of other MIT officials, Townes joined the boards of the RAND Corporation, a defense-oriented think tank; the Salk Institute for Biological Studies, a research lab founded by the inventor of the first polio vaccine; and the Carnegie Institution of Washington, which conducts research in both astronomy and genetics. At the time, Townes wanted to serve only on nonprofit boards, not those of large corporations.

Advising the U.S. government

Around 1960, Townes helped start Jason, a group of elite American scientists who received security clearances so that they could access classified studies and advise top U.S. officials on pressing issues of the day, such as the Vietnam War. (The group was named after the Greek mythological hero who led the quest for the Golden Fleece.) Operating in secret meetings, members of Jason studied all sorts of far-flung scenarios, such as the

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OSA Honorary Member Charles Hard Townes cleans one of the ISI array's telescope mirrors with a jet of compressed carbon dioxide.

Cristina Ryan

feasibility of using tactical, low-yield nuclear weapons in Southeast Asia.

Many Jason members did not sympathize with U.S. policy in Vietnam, Townes later wrote in his memoir, *How the Laser Happened*. Hoping to reduce the intensity of the bombing, in 1966 Jason proposed a network of electronic microphones and tiny land mines to seal the border of South Vietnam against North Vietnamese infiltrators and suppliers. The U.S. defense secretary, Robert McNamara, endorsed the plan and ordered its construction. However, the "McNamara Wall" did not perform well, and work ceased on it late in 1968.

Townes did not help plan the wall because he had stepped away from Jason for a few years, but, as he later wrote, he reconnected with the group as internal tensions grew over the rift between U.S. government policy and the increasingly antiwar sentiment within academia. Townes resigned from a McNamara Wall subpanel after a couple of meetings.

Another of Townes' consultative roles had a happier outcome. In 1963, the head of the Apollo program, George Mueller, invited Townes to organize a scientific advisory panel to aid NASA's race to land a man on the moon. Townes headed Apollo's scientific advisory committee from 1966 through 1970, the year after the first two lunar landings. "He was very much in favor of putting a man on the moon, and there were a lot of scientists who were against that," says his daughter Ellen Townes-Anderson, professor of neurology and neurosciences at Rutgers New Jersey Medical School, USA.

Even the Apollo panel scientists disagreed on the feasibility of lunar landings. One astrophysicist, the iconoclastic Thomas Gold of Cornell University, USA, argued that a deep, fluffy layer of dust particles had built up on the moon's surface, and any spacecraft attempting a surface landing would sink out of sight. Townes consulted other scientists who presented evidence from radar and ultraviolet reflectivity measurements to demonstrate that wouldn't be the case.

As Townes wrote in his memoir, the committee came up with the idea for the lunar surface rover that accompanied the last three Apollo crews, as well as the corner-cube laser reflector experiments to measure the Earth-moon distance accurately. However, Townes also regretted that the committee never pondered the possibility that the all-oxygen atmosphere of the first Apollo capsule might lead to the fatal launch-pad fire in January 1967.

During the 1980s, Townes chaired yet another advisory panel, this one assigned to find sites for a new type of intercontinental ballistic missile called the MX missile. Ultimately, after the committee met with President Ronald Reagan, the U.S. Department of Defense decided to deploy fewer MX missiles than originally planned. Townes, a friend of then-Defense Secretary Caspar Weinberger, also offered his counsel on the Strategic Defense Initiative (the so-called "Star Wars" anti-missile program) and other issues of the late Cold War period.

Several times over the years, Townes took under his wing graduate students who had clashed with their previous advisers and allowed them to flourish under his supervision.

Transition to Berkeley

In 1966, when MIT president Julius Stratton stepped down, a search committee led by Vannevar Bush, chairman of the institute's board of trustees, convened to choose Stratton's successor. Stratton had served as MIT provost before ascending to the presidency in 1959, but this time around, Bush's panel chose the dean of the business school, Howard Wesley Johnson, over Townes. (In an oral-history interview, Townes speculated that his reluctance to join the boards of commercial firms might have counted against him.) Townes was surprised at the decision but realized that it gave him the chance to devote more time to research. He stepped down from the post of provost and started spending some of his time at the astronomy department of nearby Harvard University.

Hoping to lure a prominent Nobel laureate, a number of universities and a couple of large corporations offered Townes research and administrative jobs. Ultimately, he chose to join the physics department at the University of California, Berkeley. Not only did Townes find northern California a pleasant place to live, but Berkeley also presented many opportunities for astronomy research.

At Berkeley, Townes served as a doctoral adviser to a number of students, including OSA Fellow Robert W. Boyd, now of the universities of Ottawa (Canada) and Rochester (USA). Townes "gave students a lot of freedom, and a lot of his students were quite self-motivated and had some interesting ideas and he let them pursue their ideas," says Ed Wishnow, a researcher at Berkeley's Space Sciences Laboratory, where Townes spent his time when he wasn't at the physics department. Several times over the years, Townes took under his wing graduate students who had clashed with their previous advisers and allowed them to flourish under his supervision.

"We all know when we've done our best work and when we haven't, and he would push us, but in a very kind way," Wishnow said of Townes. "He understood what good work was and how to bring out the best in people."

Astrophysics and interferometry

Townes "had a lot of confidence to go out and try new things," Wishnow says. Although the laser scientist had dabbled in astronomy in his Columbia and Bell Labs days, he was eager to turn much more of his attention toward astronomical observations in the infrared, microwave and radio bands of the spectrum. During his years as MIT provost, another MIT scientist had detected the OH^- radical in space, but astronomers generally believed that only a few other diatomic species existed out there.

Townes pointed one of Berkeley's Hat Creek Observatory radio dishes at a cluster of dark clouds near the center of the Milky Way and found the telltale spectroscopic signature of ammonia—the first polyatomic molecule found

in insterstellar space. Shortly thereafter, he detected water in the same cloud complex, as well as a giant water maser lurking in the Orion Nebula.

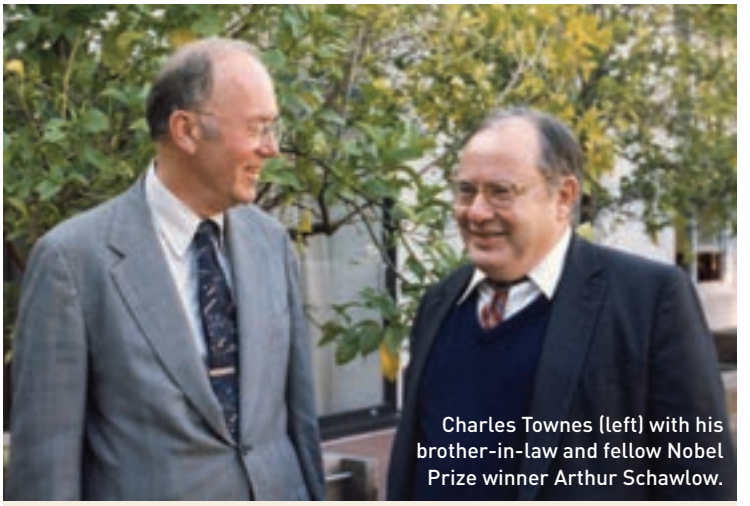
Later, Townes developed precision spectroscopy techniques to map the rotation of gases around the galactic center, which eventually led to the first measurements of the mass of the black hole at the center of our galaxy—innovative work for the early 1980s when much less was known about the region, according to Wishnow. He also worked on instruments for the Kuiper Airborne Observatory, a jetliner outfitted by NASA for infrared astronomy above most of the water vapor in Earth's atmosphere.

In the 1970s, Townes became interested in studying thermal radiation in the mid-infrared region, which would allow for the mapping of cool dust shells around stars. Originally, Townes and his students built the first mid-infrared interferometer using two auxiliary telescopes on the McMath Solar Telescope at Kitt Peak National Observatory in Arizona (USA). After that proof of concept, the team built the Infrared Spatial Interferometer (ISI) at Berkeley, an array of two (or three, beginning in 2003) Pfund-type optical telescopes whose signals are down-converted by mixing with a fixed-frequency local oscillator (a carbon-dioxide laser). This scheme, called heterodyne detection, comes from the subfield of radio astronomy; by contrast, the twin 10-m Keck telescopes in Hawaii use direct detection, which combines the light beams from the pair.

In 2009, Townes and Wishnow presented 15 years' worth of ISI observations of Betelgeuse, showing that the red supergiant star had been mysteriously shrinking in diameter. (Most stars appear only as pinpoints even in the best telescopes; Betelgeuse is one of the few big and relatively close stars to present Earth's scientists with a measurable apparent angular diameter.) In the last few years, though, Betelgeuse has swelled back to its previous size, Wishnow said.

Religion and community service

According to Townes-Anderson, Townes was raised in the Baptist denomination of Christianity, but he attended other types of Christian



Charles Townes (left) with his brother-in-law and fellow Nobel Prize winner Arthur Schawlow.

AIP Emilio Segrè Visual Archives, Segrè Collection

Family Matters

Balancing family life and research pursuits can be challenging for high achievers. It's a challenge that Charles Townes met, according to the second of his four daughters, Ellen Townes-Anderson.

"We had every evening meal together. The sense of family was absolutely there, and family meant a great deal to him, and we knew that. Although he wasn't around all the time, I think we all felt very supported and loved by him."

Throughout the scientific community, Charles and Frances Townes, married since 1941, were famous for traveling together. One of their great joys, Townes-Anderson says, was their love of bird observing. A lifetime member of the National Audubon Society, Charles Townes sometimes chose conference invitations based on the chance that he might be able to add another species to his "life list."

One side benefit of the family's move to Berkeley in 1967 was that it placed them across San Francisco Bay from the family of his one-time Columbia University collaborator, 1975 OSA President Arthur L. Schawlow. One of Townes' sisters, Aurelia, was married to Schawlow.

Their daughter, Helen Schawlow Johnson, has her favorite "Uncle Charlie" memory, which she says illustrates his sense of humor. It took place the first Christmas after he arrived in Berkeley.

"Uncle Charlie had found just the thing for all of us, the latest cool thing from the Berkeley streets—prismatic sunglasses, a.k.a. LSD glasses," she says. "Now, no one in the room ever touched LSD, of that I am sure, but we all knew about it because we lived in the Bay Area in the 1960s. My father put 'Yellow Submarine' on the stereo and we all whipped on our glasses. Picture Arthur Schawlow and Charles Townes and their respective families wearing LSD glasses, tilting their heads this way and that at each other, taking in all the colors."

His brother-in-law might have had a penchant for practical jokes, but Townes was more of an inveterate punster, according to Townes-Anderson. A favorite joke of his spoke to his awareness of the role his work played in the history of 20th-century science.

"He talked of the importance of pure science and described a cartoon he liked, which shows a tiny rabbit and beaver looking up at Hoover Dam," Townes-Anderson says. "The beaver is saying to the rabbit, 'No, I didn't build it, but it was based on an idea of mine!'"

churches. While at Columbia University in New York, he served as a deacon at the interdenominational Riverside Church. During the family's MIT years in Cambridge, he attended a Lutheran church. Finally, in California he and his wife joined the First Congregational Church of Berkeley, part of the United Church of Christ (UCC) denomination.

"What he and my mother would do is they would find the church that they felt fit them the best," Townes-Anderson says. "The actual brand wasn't so critical as the spirit of the place."

Two years after winning his Nobel Prize, Townes published a groundbreaking essay on his belief in the ultimate convergence of science and religion.

In 2007, at its general synod in Hartford, Conn., the UCC invited Townes to give a talk on laser history, which received a standing ovation, his daughter said. The synod also staged a laser light show—an art form that Garmire, his onetime MIT student, helped pioneer.

Two years after winning his Nobel Prize, Townes published a groundbreaking essay on his belief in the ultimate convergence of science and religion. In a magazine published by IBM, he guided readers through 19th-century scientific absolutism to the "deeply disturbing" quantum-mechanical revolution of the 1920s. He drew parallels between today's scientific understanding, which seeks to grasp the order of the universe, and religious beliefs, which seek to comprehend and accept the purpose of the universe.

Townes also highlighted a common idea between the two: the role of revelation, which he experienced scientifically when he dreamed up stimulated light emission while sitting on a park bench in 1951. "If we compare how great scientific ideas arrive, they look remarkably like religious revelation viewed in a non-mystical way," he wrote.

On occasion, Townes' views on religion have garnered controversy among scientists because they seem to skirt the views of "intelligent design" advocates who oppose teaching the theory of evolution. When he accepted the 2005 Templeton Prize for "research or discoveries about spiritual realities," however, Townes made his stand clear. "I think for religious people or politicians to oppose the teaching of evolution is absolutely wrong and stupid," he said, adding that he saw no conflict between evolution and religion.

Perhaps the least-publicized aspect of Townes' post-Nobel activities was his service as a board member of California Vocations Inc. (CalVoc), a non-profit organization providing outpatient and residential services to developmentally disabled adults. Townes had a personal reason for supporting the institution: his nephew, Arthur "Artie" Schawlow Jr., was diagnosed with autism in an era when little was known about the condition.

Townes served on the board from 1985 to 2001, according to CalVoc's executive director, Bob Irvine. "He would always listen first and then advise," says Irvine, who also served as a board member before joining the staff. "He would take the time to listen to people's perspectives and then weigh the conversation and then provide some very pointed advice, which was great for the organization."

Artie's father, 1975 OSA President and 1981 Nobel laureate Arthur L. Schawlow, and Townes would sometimes stage physics demonstrations for the CalVoc board and for the residents of Chico, the nearest city of any size. As Irvine recalls, both brothers-in-law used their contacts and influence to gain advice and resources for the institution. "We had top-notch consultants come in to assist in communication and behavior management," he says. "It helped the adults that we served tremendously and helped the staff build a high caliber of support for them." Now in his late 50s, Artie Schawlow Jr. still lives at the center.

Later years and recognition

Multiple awards and institutions have already been named in Townes' honor. OSA established the Charles Hard Townes Award for quantum electronics in 1980, the year of his 75th birthday. (OSA Fellow Joseph Giordmaine, who worked

with Townes at Columbia University, led the fundraising campaign for the award.) The University of Central Florida College of Optics and Photonics (CREOL, USA) dedicated the Townes Laser Center in 2007. Townes' undergraduate alma mater, Furman University (Greenville, S.C., USA), opened the US$62.5 million Charles H. Townes Science Center in 2008; the college also sponsors a scholarship and a lecture series on faith and reason in his name.

Townes never forgot his roots in Greenville, which named its elementary-school center for gifted and talented students after him in 2006. At its dedication, he recounted meeting the Rev. Dr. Martin Luther King Jr. at a Nobel reception in 1964, and King remembered Townes' aunt's help in the early days of his civil rights work.

Courtesy of John Ballato

Charles and Frances Townes at the 2006 Greenville, S.C., USA, dedication of a statue to honor Townes. The statue depicts Townes' moment of realization as he jots down the formula that led to the development of the maser.

In 2012, Townes became one of the first winners of the Golden Goose Award, the brainchild of a Tennessee congressman who wanted to highlight government-funded research that turned out to be transformative. Townes-Anderson says that the award agreed with her father's lifelong belief in the importance of basic scientific inquiry.

Up until the last couple of years, Townes remained vigorous for his age and worked some nights and weekends at Berkeley. "It's pretty daunting when your 95-year-old boss is putting in long hours," Wishnow says. An OSA Honorary Member since 1970, Townes made his last appearance before the community at CLEO: 2014, when he and 2012 OSA President Tony Heinz gave a joint presentation at a memorial symposium for Townes' former Columbia student, maser pioneer James P. Gordon. The symposium featured several high-profile speakers, including OSA Fellow Arthur Ashkin, OSA Fellow Gary D. Boyd, OSA Fellow and Nobel laureate Steven Chu, OSA Fellow Linn Mollenauer, Nobel laureate Arno A. Penzias and OSA Fellow Mark Shtaif.

To celebrate Townes' 99th birthday in 2014, both the Berkeley campus and Greenville issued proclamations declaring 28 July "Charles H. Townes Day." By then, declining health had forced Townes onto supplemental oxygen, but he and his wife, Frances, rode a golf cart to the Berkeley physics department festivities on the Faculty Glade and enjoyed birthday cake and music in his honor.

Townes' death on 27 January brought to an end almost a century of scientific insight, service to society and philosophical musings that could have filled the lifetimes of several other people. His legacy in physics and philosophy will continue into the next century. OPN

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