Daniel Kleppner, prize-winning physicist, dies at 92

The MIT professor, a recipient of the National Medal of Science, developed technologies that helped pave the way for the Global Positioning System.

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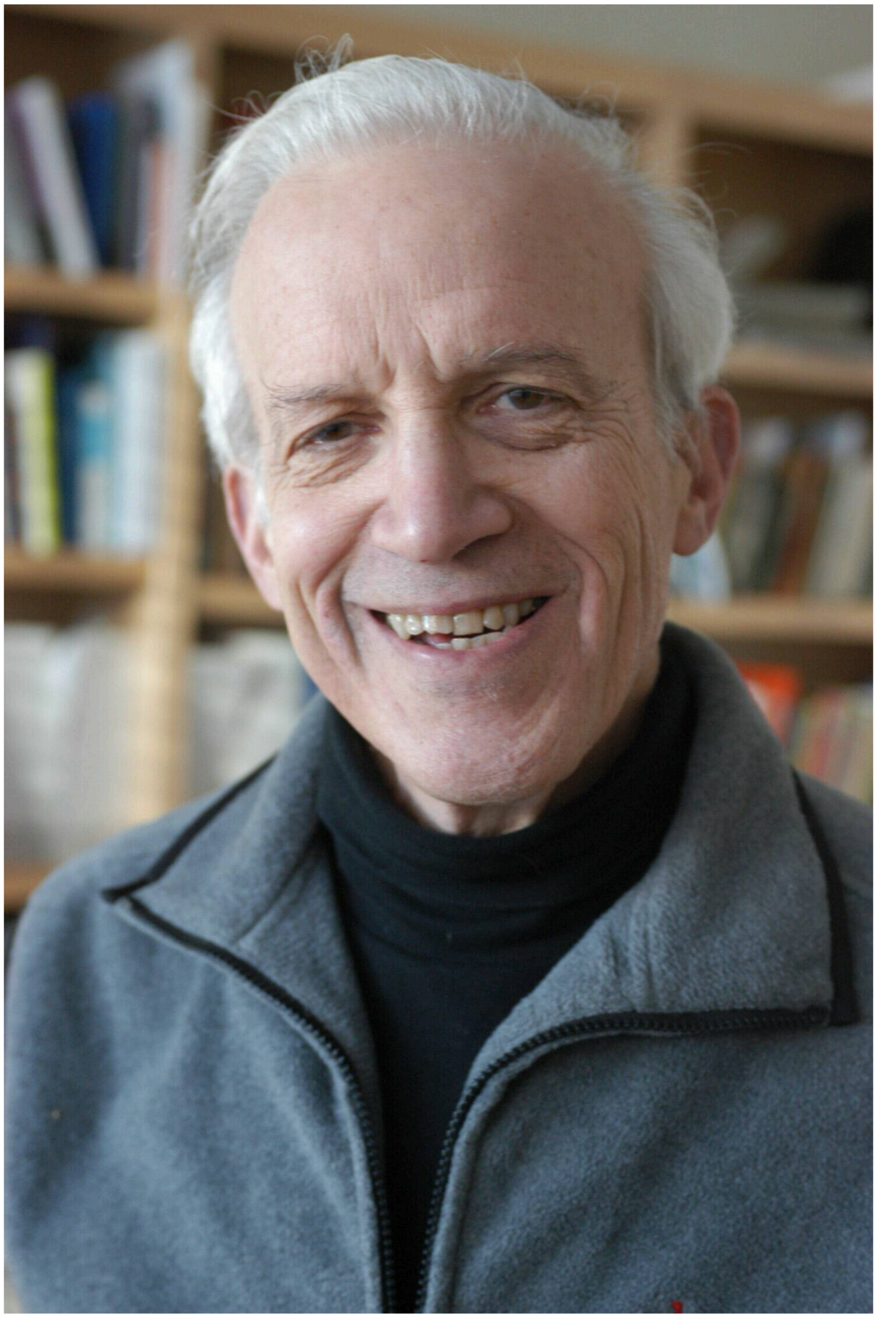


Daniel Kleppner spent nearly four decades as a professor at the Massachusetts Institute of Technology. (Donna Coveney/MIT Physics)

By Anusha Mathur

Daniel Kleppner, a highly honored physicist who developed technologies that helped pave the way for the Global Positioning System and whose foundational atomic discoveries helped open up the field of quantum computing, died June 16 at a hospital in Palo Alto. He was 92.

His wife, Beatrice, confirmed the death but did not provide the cause.

Dr. Kleppner spent nearly four decades as a professor at the Massachusetts Institute of Technology. He began his contributions in atomic physics as a doctoral student at Harvard University in the late 1950s under physicist and future Nobel laureate Norman F. Ramsey.

Ramsey was intent on developing an atomic clock, a device accurate enough to measure the effect of gravity on time. However, preexisting technologies, such as cesium and ammonia masers, were not precise enough to accomplish this. (A maser is a technology of amplified microwaves.)

Dr. Kleppner's research on hydrogen — the simplest, lightest and most abundant chemical element in the universe — helped Ramsey achieve this goal. Dr. Kleppner successfully devised a method to keep hydrogen atoms locked away in a glass container so their delicate quantum properties could be studied over a longer period of time, thereby making time measurements more precise.

This hydrogen research allowed Ramsey and Dr. Kleppner to coinvent the hydrogen maser in 1960, one of the most stable atomic clocks ever built. Its unprecedented precision in timekeeping made it foundational to the development of GPS nearly two decades later, as the world's satellites were synchronized using these atomic clocks.

"Hydrogen masers made it possible for the people who developed GPS to even think about it," said William Phillips, a physicist at the National Institute of Standards and Technology. "If you hadn't had clocks that were that good, then you wouldn't have been able to imagine making a system that relied on a network of clocks that are all synchronized and keeping the same time."

Hydrogen masers are still employed by naval observatories for timekeeping and communication and are coupled with newer technology in modern GPS systems to enable billions of people to navigate the Earth.

"When we first set out to make these atomic clocks, our goals were about the least practical you can think of," Dr. Kleppner said in an interview with the MIT physics department. "From being a rather abstract idea that you'd like to somehow witness, it becomes a very urgent thing for the conduct of human affairs."

On the MIT faculty starting in 1966, Dr. Kleppner conducted some of the first research on Rydberg atoms — a highly excited atom that shares the simple properties that define hydrogen. His seminal paper published in 1976 jump-started interest in the field. Many scientists consider the modern Rydberg quantum computer to be the most promising platform in the burgeoning field of quantum computing.

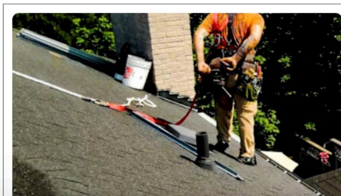
“He did the groundwork, the basic understanding of what Rydberg atoms can do, and that has eventually in the last 15 years been developed into a new platform, a new approach for quantum computation,” MIT physicist Wolfgang Ketterle said. “That has led to multimillion-dollar funding in multiple start-up companies in Europe and the U.S.”

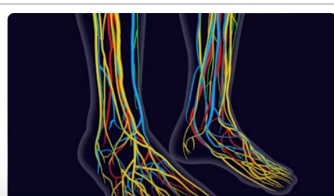
In 1976, Dr. Kleppner also became interested in ultracold gases, specifically a strange quantum state of matter that occurs at near absolute zero known as Bose-Einstein condensation.

“We always make discoveries in physics because we take nature beyond the limits where it has been explored,” Ketterle said. “Bose-Einstein condensation was synonymous with the journey to absolute zero temperature.”

Absolute zero was a proverbial “white whale” of atomic physics, as it was predicted in the 1920s but had never been realized. However, a new paper suggested that it may actually be achievable in hydrogen.

“Dan had a lifelong love affair with hydrogen,” Phillips said. “Dan seemed like he wanted to squeeze every bit of information that you could out of this simplest atom.”





Dr. Kleppner approached Tom Greytak, a low-temperature physicist, to collaborate on reaching Bose-Einstein condensation in hydrogen. They tested two revolutionary techniques — magnetic trapping and evaporative cooling.

“This is where the two aspects of Dan Kleppner’s work connect,” Ketterle said. “Kleppner is famous for the hydrogen maser, which was the beginning of practical atomic clocks. But now we have clocks that are 10,000 times more accurate than the hydrogen maser. But those clocks are more accurate because they operate at extremely low temperature, and the techniques developed to reach Bose-Einstein condensation are now applied to atomic clocks.”

Dr. Kleppner and Greytak had trouble getting hydrogen to cooperate but shared their methodology with the scientific community. Ketterle’s team implemented Dr. Kleppner’s techniques on sodium to achieve Bose-Einstein condensation and earned a Nobel Prize. Ketterle remembers attending a conference shortly after winning where Dr. Kleppner talked about his pursuit of Bose-Einstein condensation in hydrogen.

“He described his own contribution with the following words: ‘I feel like Moses, who showed his people the Holy Land, but he never reached it himself,’” Ketterle said. “This was exactly what Dan did. He showed us the Holy Land of Bose-Einstein condensation. He showed us what is possible. He got us started.”

A year later, in 1998, Dr. Kleppner and his team finally created a Bose-Einstein condensate in hydrogen and announced it at a conference to a standing ovation. When he received the National Medal of Science in 2006, Dr. Kleppner was named “the godfather of extra-cold atoms.”

Following this success, Dr. Kleppner helped start the Center for Ultracold Atoms, an MIT-Harvard collaboration funded by the National Science Foundation to research atomic physics.

He also co-chaired a major study by the American Physical Society on boost-phase missile defense, an effort to intercept enemy missiles as they are struggling with liftoff and moving relatively slowly.

Daniel Kleppner, the second of three siblings, was born in Manhattan on Dec. 16, 1932. His father, who founded and chaired an advertising agency, wrote the best-selling book “Advertising Procedure.” His mother became her husband’s amanuensis, helping him with his manuscripts.

A self-described tinkerer who built slot machines and rowboats as a child, Dr. Kleppner said he knew by high school that he was “destined to spend a life in physics.”

He preferred staying late in the science lab to cheering at the football game pep rally — a choice that earned him a scolding from the school principal for his lack of school spirit. His high school science teacher tutored him in calculus after hours.

“Physicists were heroes because of the development of the atomic project and because of the development of radar,” Dr. Kleppner said in an interview for the InfiniteMIT archive. “It was an easy era to become delighted by physics, and I was.”

During his years at Williams College in Massachusetts, Dr. Kleppner became fascinated by Albert Einstein’s theory of general relativity: the idea that time moves faster higher up in the atmosphere.

“When I first heard the idea that gravity could change time, it seemed to be totally extraordinary,” Dr. Kleppner told the Franklin Institute, a science museum in Philadelphia that awarded him the 2014 Benjamin Franklin Medal for physics. “We really don’t have that much intuition about time. Time just flows by. We can’t do much about it, so there’s always something strange and slightly mystical.”

He graduated from Williams in 1953 and was accepted to a fellowship at the University of Cambridge in England. He received a doctorate from Harvard in 1959 and then was a postdoc at Harvard until joining MIT. He retired in 2003.

His honors included the Wolf Foundation prize for physics and the American Physical Society’s

Lilienfeld Prize.

In 1958, he married Beatrice Spencer. In addition to his wife, Dr. Kleppner is survived by three children, Sofie, Paul and Andrew; a sister; and four grandchildren.

Dr. Kleppner died while attending his grandson Darwin's high school graduation party. His daughter said that his last words before being rushed to the hospital were a toast to the future of science: "To Darwin and all youth who will be having new and exciting ideas."

Anusha Mathur is a reporter on the Climate/Environment (Futures) team, covering climate science, climate solutions, and environmental policy. She also contributes to the Washington Post's Obituaries desk. She has previously covered politics in Washington D.C.