humor as deep and dry as his Beefeater martinis. His group members knew his dedication to them; Harden convinced more than one despondent student to finish a dissertation, and he wrote recommendation letters even after being informed of his terminal illness. In total, Harden advised 79 PhD students and 71 postdoctoral fellows. His account of his group's accomplishments is at http://hardenmcconnell.org.

The urgency of time weighed on Harden throughout his life—he had a nervous habit of jingling keys during unstimulating seminars. In the end, he was right. There was not enough time. The day before he died, his characteristically terse and curious email to a former student regarding a manuscript read, "para 2 is not terrible anymore. Anything new?" We miss him profoundly.

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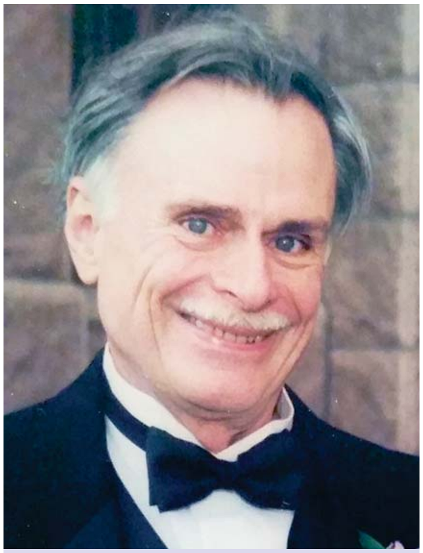
John Stewart Waugh



John Stewart Waugh

John Stewart Waugh, a chemical-physics authority recognized as the founder of the field of high-resolution nuclear magnetic resonance (NMR) in solids, died from complications from Alzheimer's disease in Lincoln, Massachusetts, on 22 August 2014.

John was born on 25 April 1929 in Storrs, Connecticut, and was raised near the University of Connecticut, where his father, who sparked his interest in science, was a professor of economics and statistics. After high school, John attended Dartmouth College; he graduated in 1949 with highest distinction in chemistry. He then went to graduate school at Caltech, where his thesis supervisor was Donald Yost and his research focused on a topic discovered about three years earlier—NMR. As part of his thesis, "Line profiles in nuclear magnetic resonance absorption," John assembled a continuous-wave NMR instrument.

After receiving his PhD in chemistry and physics in 1953, John returned to the East Coast to be an instructor in the chemistry department at MIT. He was promoted to assistant professor in 1955 and rose through the academic ranks; in 1989 he became an institute professor, the highest honor that MIT bestows on its faculty.

During his first 15 years at MIT, John focused his research on various intriguing problems in chemistry and physics that arose during the early years of NMR. For example, he explained the anomalous chemical shifts in ^{1}H NMR spectra of aromatic molecules, coupling in strongly interacting spin systems, and relaxation in liquids and gases. In 1968 he introduced a method for using Fourier-transform spectroscopy to measure spin–lattice relaxation times T_1 in complex spin systems. That "inversion recovery" technique remains the method of choice for calculating spin–lattice relaxation rates in gases, liquids, and solids.

In 1966 John and engineer Edward Ostroff, who worked at spectrometer manufacturer Magnion, serendipitously discovered that applying a train of intense RF pulses to a spin system in a solid would extend the length of a free induction decay. That led in 1968 to a series of three articles by John, with various coauthors, on multiple-pulse NMR; those papers laid the foundations for high-resolution NMR in solids. One of them, now famous as the WAHUHA experiment, described the initial suppression of the homonuclear dipolar interactions in calcium fluoride and observation of the underlying chemical shifts and their spatial anisotropy, the feature of NMR spectra that renders the technique so useful to physics, chemistry, and biology.

Equally important, John and Ulrich Haeberlen introduced a theoretical framework to understand the experiments: the average Hamiltonian theory (AHT), an especially powerful form of time-dependent perturbation theory. Today AHT provides the intellectual underpinnings for spin decoupling, recoupling, and many other stimulating ideas in magnetic resonance and other fields. It is considered an intellectual triumph and the most important theoretical approach in the field.

In the early 1970s, John, together with graduate students Alexander Pines and Michael Gibby, published a paper demonstrating that high-resolution NMR experiments could be extended to observe carbon-13, nitrogen-15, phosphorus-31, and other nuclei with smaller dipolar couplings. The experiment's central feature was the transfer of polarization from abundant spins, namely ^{1}H, to the other nuclei. That circumvented the problematic long T_1 of the nuclei. A second feature they incorporated was ^{1}H decoupling, which ensures high resolution. Today that seminal approach to high-resolution NMR is routinely used in labs worldwide.

Subsequently, John and his colleagues combined the experiment with multiple-pulse NMR in a manner that reintroduced high-resolution dipole couplings into NMR spectra. That approach allows measurement of internuclear distances. Integration of magic-angle spinning led to what is today known as dipole recoupling, which permits the determination of protein structures in membranes and amyloid fibrils.

John is remembered fondly for his well-developed sense of humor. He called the method outlined in his seminal paper on multiple-pulse NMR the WAHUHA experiment after the three authors: Waugh, Huber, and Haeberlen. Following the abandonment of "cycles/second" for the hertz in the early 1970s, John rescued "radian/second," the preferred unit in all magnetic resonance calculations, by defining a new unit, the As, so that 1 Hz = 2π As. Aficionados of magnetic resonance use the As to express angular velocity in inverse seconds, or an "Avis."

An avid sailor, John owned many sailboats, including one aptly named *Magic Angle* and a dinghy called *Spin Echo*. With Susan, his wife of 31 years, he sailed the coast of Maine, traveled, and raised a succession of beloved Labrador retrievers.

John Waugh was a towering figure in NMR and electron paramagnetic resonance, and his intellect, achievements, and wonderful sense of humor were an inspiration to those who knew and worked with him. He will be sorely missed by all of us in the magnetic resonance community.

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