vast overlapping network of family, friends, colleagues, and collaborators. We deeply miss his generosity and his friendship.

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John Leask Lumley

John Leask Lumley, the Willis H. Carrier Professor Emeritus of Mechanical and Aerospace Engineering at Cornell University who made seminal contributions to the physics and engineering of turbulent fluid flow, died from brain cancer on 30 May 2015 in Ithaca, New York.

John was born on 4 November 1930 in Detroit, Michigan. His lifelong appreciation of engineering design was encouraged by his father, an architectural engineer. John received his BA in engineering sciences and applied physics from Harvard University in 1952. He earned his master's in 1954 in mechanical engineering and his doctorate in aeronautical engineering, under Stanley Corrsin, in 1957, both from the Johns Hopkins University. In 1959 he joined the Pennsylvania State University, where he rapidly rose to be the Evan Pugh Professor of Aerospace Engineering in 1974 at age 44. He was the youngest to ever hold that prestigious title.

At Penn State, John developed his unique style as a theoretician, modeler, and experimentalist. In 1977 he accepted an offer from Cornell University. He, his wife, and their three children moved into a rambling old Victorian home with a pond. They renovated the kitchen and thus could pursue their love of cooking and food, which began during John's first sabbatical to Marseille, France, in 1966. Ithaca provided physical beauty, and Cornell offered John intellectual challenge and enduring friendships.

John Leask Lumley

It is difficult to think of a facet of turbulence, whether it is formal mathematical theory, fundamental physics, or engineering and environmental applications, to which John did not make seminal contributions. Although others may have probed as deeply, we can think of no other who has covered the whole gamut, from Hölder continuity to hotwire circuitry. In each sphere John's reach was broad. On the applied side, he wrote on drag reduction, buoyant plumes, gravity wave–turbulence interaction, turbulence in the presence of stable stratification, and the effects of electromagnetic fields on turbulence, among other things. He even wrote a paper on flow through a teat canal in a dairy cow.

John's fundamental contributions span mathematics, stochastic processes, spectral dynamics, and the dynamics and modeling of all the generic flows. He pioneered the proper orthogonal decomposition approach that unambiguously extracts structures from turbulent flows, which though random contain structures that occur repeatedly, and orders them according to their energy content. That approach provides a mathematically optimal description that can be used to construct low-dimensional models of the flows.

With his students, he made several experimental contributions to the understanding of atmospheric turbulence, particles in turbulence, and shear flows. In 1990 he received the Fluid Dynamics Prize from the American Physical Society.

John was also a great educator. Although not known as a colorful lecture-room expositor, he influenced generations of students through his six books, his papers, and his films. His pathbreaking book *A First Course in Turbulence*, written with Hendrik Tennekes (MIT Press, 1972), was the first book to place dimensional analysis and scaling arguments as central to the subject. He had a lifelong passion for rebuilding old cars and wrote *Still Life with Cars: An Automotive Memoir* (McFarland & Co, 2005). He also provided editorial services to the *Annual Review of Fluid Mechanics* for 30 years, 19 of them as coeditor.

During the Cold War, Soviet scientists had developed turbulence theory and experiment significantly further than their counterparts in the West. John brought their advances to the attention of Western scientists by editing English translations of the two-volume treatise *Statistical Fluid Mechanics: Mechanics of Turbulence*, by Andrei Monin and Akiva Yaglom (MIT Press, 1971, 1975), and the *Izvestiya, Atmospheric and Oceanic Physics* journal series of the Soviet Academy of Sciences. After he caught the Soviets' attention with his 1964 book with Hans Panofsky, *Structure of Atmospheric Turbulence* (Wiley), John's work garnered much admiration in the USSR. He made several trips behind the Iron Curtain and met many prominent Soviet scientists.

John's writing style was, like the man, idiosyncratic and hard to pin down. It was both rigorous and intuitive. While the prose was elegant and often amusing, there was sometimes a sketchiness that reflected, no doubt, his impatience. He worked quickly and didn't look back. Some of his best papers were only one or two pages long. And his output was prodigious. Despite having strong views on the intellectual course of a subject, he was always ready to recognize innovative approaches and findings; he often used the word "cute" to describe something that particularly appealed to him. He was ready to drop pet theories if they did not measure up observationally.

However well one knew John, it was difficult to take him for granted; he was rarely spontaneous and was reticent in public. It was clear that he was intellectually special, never the one to toe the line of authority. Not only his long-standing colleagues but all of us in the field of turbulence will miss him greatly.

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Yoichiro Nambu

On 5 July 2015, at the age of 94, Yoichiro Nambu, one of the truly great theoretical physicists of our time, died in Osaka, Japan, due to an acute myocardial infarction.

Most of the important physics theories of the second half of the 20th century contain a seminal contribution by Yoichiro. We mention but three: spontaneous symmetry breaking, color gauging, and string theory, which all owe their existence to Yoichiro's deep insights. Indeed, when an idea is introduced in particle physics, it often turns out to have been already developed by Yoichiro years earlier. He was the recipient of virtually all major physics prizes, including the Nobel Prize in Physics in 2008 and the Wolf Prize in 1995. But such was the modesty of the man that one always thought of him as the creator of this or that fundamental theory and not as a Nobel or other prize laureate.

Yoichiro was born in Tokyo on 18 January 1921. His youth was affected by World War II. He served in the Japanese Army and was assigned to keep an eye on Sin-itiro Tomonaga, who was developing radar for one of the other military services. That assignment brought Yoichiro in contact with Tomonaga's physics ideas, and after the war, though not a member of his group, Yoichiro kept up to date with its work. He set out on his own to calculate the electron's anomalous magnetic moment and obtained the famous $\alpha/2\pi$ correction. He was not aware of similar work elsewhere because Douglas MacArthur, to make sure the Japanese did not develop nuclear weapons of their own, forbade the import of US physics journals to Japan. Instead, he encouraged the Japanese to read *Time* magazine. It was in *Time* that Yoichiro read an article about Julian Schwinger's calculation of the electron's anomalous magnetic moment, which reached the same result as the one he had obtained and which thereby made Yoichiro's work no longer publishable.

Two years before receiving his PhD from Tokyo Imperial University in 1952, Yoichiro was appointed an associate professor at Osaka City University. In that capacity he published two papers whose results are often quoted under the names of physicists who rediscovered them. In one, Yoichiro derived the quantum field theoretic bound-state equation usually known as the Bethe–Salpeter equation. In another, with Kazuhiko Nishijima and Yoshio Yamaguchi, he proposed the mechanism of associated production of strange particles a year before Abraham Pais did.

Yoichiro realized that the center of worldwide theoretical physics research was in the US, and in 1952 he went to the Institute for Advanced Study in Princeton, New Jersey. In 1954 he moved to the University of Chicago, where he would spend the rest of his career. He caught the tail end of Chicago's Enrico Fermi era.


AIP EMILIO SEGRÈ VISUAL ARCHIVES, MARSHAK COLLECTION

Yoichiro Nambu

In the mid 1950s, dispersion theory was center stage, and with Geoffrey Chew, Marvin Goldberger, and Francis Low, Yoichiro wrote the influential CGLN papers on meson scattering and photoproduction. From an analysis of the Stanford nucleon form-factor data, he predicted in 1957 the existence of the isospin-zero vector meson ω, which was confirmed in 1961.

At the University of Illinois in Urbana, the brilliant Bardeen-Cooper-Schrieffer theory of superconductivity was being developed. In an important paper, Yoichiro solved the problem of the theory's apparent lack of gauge invariance, and in the fundamental papers he wrote with Giovanni Jona-Lasinio, he transported the basic idea of that work into relativistic quantum field theory. Those contributions marked the birth of the fundamental theory of spontaneous symmetry breaking and also led to the Brout-Englert-Higgs mechanism by which gauge fields acquire mass.

Yoichiro made the fundamental observation that whereas the laws of nature exhibit all kinds of exact symmetries, the ground state—the vacuum—can violate those symmetries, and that by itself can result in all the effects we normally associate with symmetry breaking. The signature of the spontaneous symmetry breaking mechanism is the appearance of a massless particle, the so-called Nambu–Goldstone boson, which interacts in a characteristic manner with other particles.

In 1965, with Moo-Young Han, Yoichiro set up a model of strong interactions based on a gauge treatment of a color symmetry similar to that in Wally Greenberg's quark parastatistics. Both color gauging and spontaneous symmetry breaking are crucial to the standard model of particle physics.

Four years later Yoichiro and, independently, Holger Bech Nielsen and Leonard Susskind showed that the Veneziano four-point amplitudes and their N-point ($N > 4$) generalizations call for abandoning the picture of point-like elementary particles and replacing it by extended one-dimensional objects, strings. That work has led to a vast scientific enterprise still going strong today.

Yoichiro approached physics with his characteristic deep and creative curiosity and took great pleasure in his work. His keen insights were driven by a marvelous and unique form of intuition. His reasoning was clear and convincing, but it was hard to find out how those superb ideas arose in his thinking.

In a typically Japanese manner, Yoichiro was unable to use the word "no." Even if a preposterous request was made of him, he would finally "agree" to it, but the more preposterous he found the request, the longer the time he took before saying yes. A "yes" delivered after an infinite pause was his version of the word "no." That led to some funny situations while he was chair of the University of Chicago department of physics.

At a personal level, Yoichiro was a kind and understanding colleague, who established a pleasant and cordial atmosphere at the Enrico Fermi Institute. With his passing, we lose one of the few dominant figures who set the direction in which theoretical physics is evolving.

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Emil Martinec
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