obituaries

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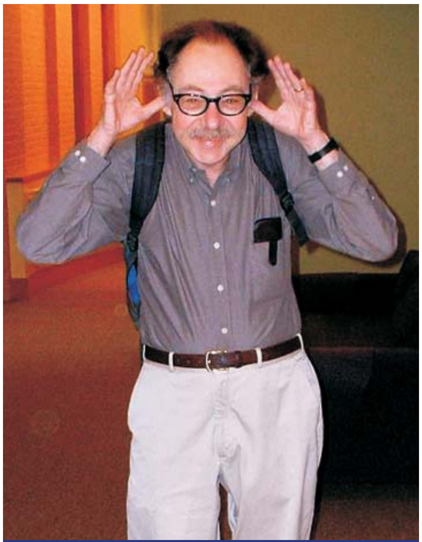
Sidney Richard Coleman



Sidney Richard Coleman

Cherished friend, colleague, and collaborator Sidney Richard Coleman, Donner Professor of Science at Harvard University, died on 18 November 2007 after a long struggle with Lewy body disease.

Sidney was born on 7 March 1937 in Chicago, where he grew up. In 1957 he received his BS degree in physics from the Illinois Institute of Technology, then entered graduate school at Caltech. We met in 1960 while I spent a postdoctoral year there. By then Sidney was just beginning his doctoral research under Murray Gell-Mann. We became fast friends with common interests in science fiction and in climbing Mount Wilson on weekends to escape the Pasadena smog. Our scientific collaboration began when Gell-Mann (and independently, Yuval Ne'eman) devised the unitary-symmetry scheme. While most of our colleagues were put off by the unfamiliar math, we became traveling disciples of the Eightfold Way and its sequels, such as the eponymous Coleman–Glashow mass formula. Sidney's 1962 thesis, "The Structure of Strong Interaction Symmetries," began with a presciently apt quotation from *Justine* by the Marquis de Sade: "What we do here is nothing to what we dream of doing." So it would be!

In 1962 Sidney accepted an instructorship at Harvard. Throughout the 1960s we often traveled together to Europe, most frequently to Erice, Italy, to visit Antonino Zichichi's subnuclear school, where Sidney could be counted on to present a formidable series of lectures. Many of those lectures are published in *Aspects of Symmetry* (Cambridge University Press, 1985), a book that remains essential reading to aspiring particle theorists.

To the world at large, Sidney is hardly as well known as such popular expositors of science as Isaac Asimov, Stephen Hawking, or Carl Sagan. But to the community of theoretical physicists he is a luminary. In the 1960s quantum field theory had lost much of its appeal. Whatever its great success for electrodynamics, QFT seemed unable to deal with the host of new particles being found and the puzzles they posed. Having devolved into a formal scheme of manipulating diagrams and following rules, the underlying physics was obscured. Sidney was, in large measure, responsible for the rebirth of QFT and thus laid the foundation for today's standard model. Throughout the 1970s and beyond, Sidney understood quantum physics more deeply than most of his colleagues.

Although he collaborated with students on many of his papers, Sidney usually wrote them, as evidenced by their wit and lucidity. Of Sidney's many significant contributions, I offer three examples.

The 1967 Coleman–Mandula theorem showed that no conventional Lie algebra could nontrivially incorporate both spacetime symmetries and such internal symmetries as charge conservation. That no-go theorem showed that many then-popular speculations were senseless.

The 1973 Coleman–Weinberg analysis of radiative corrections and spontaneous symmetry breaking, along with Sidney's Erice lecture the following year on spontaneous symmetry breakdown and gauge fields, was an enormous contribution to our understanding of QFT. Previously, spontaneous symmetry breaking had to be put in explicitly via the Higgs mechanism. Sidney and Erick Weinberg showed how it could emerge from an effective potential $V(\varphi)$ obtained by incorporating quantum radiative corrections, and, moreover, they showed that this potential is indeed the vacuum energy density in a state for which the field has expectation value φ.

Sidney's papers "The Fate of the False Vacuum" parts I and II, the latter with Curtis Callan, and a third, "Gravitational Effects of and on Vacuum Decay," with Frank De Luccia, make up another remarkable achievement. The titles tersely and clearly summarize the papers, as do all of Sidney's sometimes whimsical titles. The potential of a quantum theory may have more than one minimum. Sidney calculated the decay rate of a higher (false) minimum: to lowest order in part I, with quantum corrections in part II, and in an expanding universe in the third paper. That work is central to many subsequent developments in both particle physics and cosmology.

Sidney's fundamental contributions to our understanding of QFT earned him the 1990 Dirac Medal from the Abdus Salam International Centre for Theoretical Physics and the American Physical Society's 2000 Dannie Heineman Prize.

At Harvard, Sidney was a much-sought-after research supervisor. Most of his 40 or so thesis students are now well-known scientists. For more than four decades, virtually all physics students at Harvard—both graduate and undergraduate—have been inspired by Sidney's wonderfully coherent and

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Arthur C. Clarke
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Pat Williams
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Hans Pieter Roetert Frederikse
13 July 1920 – 6 March 2008
Frederick Seitz
4 July 1911 – 2 March 2008
Carl R. Robbins
1924 – 28 February 2008
Ralph Peck
23 June 1912 – 18 February 2008
Charles Feldman
1925 – 15 February 2008
Boris Chirikov
6 June 1928 – 12 February 2008
John Porter Hoey
6 May 1927 – 8 February 2008
Ian Mackintosh
20 April 1927 – 8 January 2008

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witty presentations of quantum mechanics and quantum field theory. Some of his legendary lectures were recorded for posterity; others were saved as lecture notes by diligent students so that their successors might have a taste of Sidney's inimitable style.

In 2005 Harvard hosted a festival to honor Sidney. In attendance were many of his former students and many distinguished physicists. Steven Weinberg remarked that "Sidney is a theorist's theorist. He has not been so much concerned with accounting for the latest data from experiments as with understanding deeply what our theories really mean. I can say I learned more about physics from Sidney than from anyone else." In that connection let me recall an oft-told tale: Working late into the night as was his wont, Sidney rarely appeared at Harvard much before noon. He once arrived so late at a seminar by Weinberg that all he heard was Steve's uncertain response to a question from the audience. "I know the answer!" shouted Sidney on entering the room, "What's the question?" Indeed, he often answered questions before they were asked. Theorists who consulted him were often astounded as Sidney would patiently explain the implications of their own ideas.

Sidney was both an incomparable teacher and the most learned sage and sharpest critic in the world of theoretical physics: He was Pauli's tongue in Einstein's image. We have been deprived all too soon of one of our generation's most profound and imaginative minds.

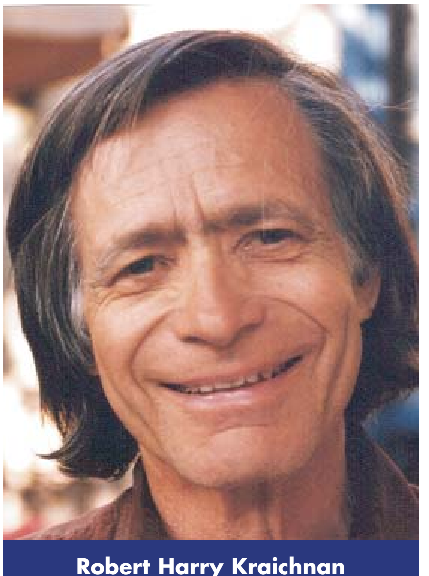
Sheldon Lee Glashow
Boston University
Boston, Massachusetts

Robert Harry Kraichnan

When Robert Kraichnan died on 26 February 2008 at his residence in Santa Fe, New Mexico, after a long illness, the world lost a profound and original theoretical physicist. He contributed much to our current understanding of fluid turbulence, the subject that occupied him for most of his career, and also made fundamental contributions to general relativity, quantum field theory, quantum many-body theory, and statistical physics.

Kraichnan was born in Philadelphia on 15 January 1928. His earliest scientific interest was in general relativity, which he began to study on his own at age 13. At age 18 he wrote at MIT a prescient undergraduate thesis, "Quantum Theory of the Linear Gravitational Field"; he received a PhD from MIT in 1949 for his thesis, "Relativistic Scattering of Pseudoscalar Mesons by Nucleons," supervised by Herman Feshbach. He was one of Albert Einstein's last assistants at the Institute for Advanced Study in Princeton, New Jersey, in 1949–50. Kraichnan developed an approach to gravitation that started from the linear wave equation of a spin-2 massless particle and recovered nonlinear general relativity by a bootstrap. His viewpoint is now popular among high-energy physicists, but Einstein viewed it with disfavor. Some of Kraichnan's ideas were rediscovered by Richard Feynman when he taught a course on gravity in 1962–63. The brilliance and strong individualist streak that were evidenced in his early work became hallmarks of Kraichnan's entire career.

After leaving the institute, Kraichnan worked at Columbia University and the Courant Institute of New York University. In the 1950s and 1960s, he made important contributions to several areas of theoretical physics, in particular to quantum field theory and the quantum many-body problem. At the time, so-called self-consistent approaches, which resummed infinite subsets of diagrams, became popular. In 1957–62 Kraichnan developed an ingenious method of realizing such approximations as exact solutions of large-N random-coupling models that couple N copies of the microscopic equations with quenched random parameters. Similar techniques using random matrices were rediscovered by Gerard 't Hooft, Alexander Migdal, and others in the 1980s and applied to chromodynamics and quantum gravity. Kraichnan's field-theoretic approach to nonequilibrium quantum statistical mechanics is equivalent to the formalism developed by Julian Schwinger and Leonid Keldysh around the same time.


Robert Harry Kraichnan

In the late 1950s, Kraichnan tackled the famously difficult subject of fluid turbulence. He became a world leader on the subject and drove major developments for a remarkable 40-year span beginning around 1957. For many workers in fluid turbulence, it was enough to say "Bob said. . . ." In 1962 Kraichnan decided on an unusual career path, leaving academia and setting up his own scientific consulting business. He became an independent research scientist, located first in New Hampshire and later in New Mexico. His work was funded by grants from agencies such as the Office of Naval Research, NSF, and the Department of Energy. He had long associations with the National Center for Atmospheric Research and Los Alamos National Laboratory.

Kraichnan made deep and seminal discoveries on turbulence in many physical systems, as varied as magnetohydrodynamics, Rayleigh–Benard convection, and superfluids. In 1957 he used the same ideas as in his work on quantum statistics to develop a self-consistent theory called the direct-interaction approximation (DIA), whose Lagrangian reformulation in 1964–66 yielded a quantitative mean-field theory of turbulence. Those works were the first to provide fundamental insights into the origin of Lord Kelvin's concept of "vitiating rearrangement" and the consequent loss of memory and eddy viscosity in turbulent flow. The DIA has been applied to diverse problems in fluid turbulence and was an important predecessor to the modern field-theory formalism of Paul Martin, Eric Siggia, and Harvey Rose.

Kraichnan also discovered the phenomenon of inverse energy cascade in two-dimensional turbulence. Building on earlier work of Lars Onsager, T. D. Lee, and others, Kraichnan predicted in 1967 that there should be a Kolmogorov-like energy cascade in 2D fluids with a $-5/3$ power-law energy spectrum but with energy transferred from small scales to large scales, the opposite direction as in 3D. That idea has proved extremely influential in our current understanding of the fluid dynamics of Earth's atmosphere and oceans. Inverse cascade has been cleanly observed in laboratory experiments in the past several years, and strong evidence has