Robert Harry Kraichnan
15 January 1928 – 26 February 2008
Santa Fe, New Mexico and
The Johns Hopkins University
Baltimore, Maryland

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

Robert H. Kraichnan was born in Philadelphia on Jan. 15, 1928. His earliest scientific interest was in general relativity, which he began to study on his own at age 13 out of a classic text of Arthur Eddington. Kraichnan won the Westinghouse Science Competition with a project on general relativity. At age 18, he wrote an undergraduate thesis at MIT, "Quantum Theory of the Linear Gravitational Field," 1946-47, which was a prescient piece of work. He was awarded a Ph.D. from MIT in 1949 and became one of Einstein's last assistants at the Institute for Advanced Study in 1949-1950. Kraichnan pioneered an approach to gravitation built on the linear wave equation of a spin-2 massless particle, recovering nonlinear general relativity by a bootstrap. Kraichnan's viewpoint is now popular among high-energy physicists, but was viewed with disfavor by Einstein himself. Many of Kraichnan's ideas were later rediscovered by Feynman when he taught a course on gravity in 1962-63. In a preface to the course notes, since published by Caltech, the editors noted that "Feynman's analysis was ... considerably less general than Kraichnan's". The brilliance and strong individualist streak that were evidenced in this early work became hallmarks of Kraichnan's entire career.

After leaving IAS, Kraichnan worked at Columbia University and the Courant Institute of New York University. He made important contributions to several areas of theoretical physics in the 1950's-60's, in particular to quantum field-theory and the quantum many-body problem. At the time, "self-consistent" approaches became popular, which resummed infinite subsets of diagrams. Kraichnan in 1957-62 developed a very 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 t'Hooft, Migdal and others in the 1980's, for applications to chromodynamics and quantum gravity. Kraichnan’s approach to quantum statistical mechanics encompassed both equilibrium and non-equilibrium systems and, in the latter case, is equivalent to the Schwinger-Keldysh formalism developed around the same time.

In the late 1950's Kraichnan turned to tackle one of the most famously difficult subjects in physics, the problem of fluid turbulence. Kraichnan became a world-leader in this subject, driving major developments for a remarkable forty-year span, from about 1957 to 1997. For many workers in fluid turbulence, it was enough to say "Bob said..." Those years also saw Kraichnan's career take an unusual path. He decided to leave academia and to set up his own scientific consulting business. From 1962 onward, Kraichnan was an independent research scientist, living first in the mountains of New Hampshire and later in Los Alamos and the outskirts of Santa Fe, funded by grants from US research agencies such as the NSF, ONR and DOE. Kraichnan was a consultant to Los Alamos National Laboratory for over 20 years.

Kraichnan made deep and seminal discoveries on turbulence in many physical systems—magnetohydrodynamics, Rayleigh-Benard convection, superfluids, etc. Three contributions especially deserve to be mentioned. Using the same ideas as in his work on quantum statistics, Kraichnan developed in 1957 a self-consistent theory called the “direct-interaction approximation” (DIA) whose Lagrangian reformulation in 1964-1966 yielded a quantitative mean-field theory of turbulence. These 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 also an important predecessor to the modern field-theory formalism of Martin-Siggia-Rose. A second very important discovery of Kraichnan’s was the phenomenon of inverse energy cascade in two-dimensional turbulence. Building on earlier work of Onsager, Lee and others, Kraichnan predicted in 1967 that there should be a Kolmogorov-like energy cascade with -5/3 spectrum in 2D fluids, but with energy transferred from small-scales to large-scales, just the opposite as in 3D. This idea has proved extremely influential in our current understanding of the fluid dynamics of the Earth's atmosphere and oceans. Inverse cascade has been cleanly observed in laboratory

experiments in the last several years and strong evidence has been found for the process also in the Earth's ocean and atmosphere. Finally, Kraichnan contributed a large body of important work on passive scalars in a turbulent flow, including his introduction in 1968 of an exactly soluble model of advection by a velocity field white-noise in time. In a seminal 1994 Physical Review Letter, Kraichnan proposed that the scalar field in this model should develop anomalous scaling, not captured by mean-field theory. This observation led to some of the most spectacular developments in turbulence theory in the 1990's, with successful calculations of the scaling exponents of the passive scalar by methods like ε-expansion and renormalization group. The Kraichnan Model is now widely hailed as the "Ising Model of turbulence".

Robert Kraichnan was a member of the US National Academy of Sciences, received the Médaille de l'ADION of the Observatoire de Nice, the Otto Laporte Award of the APS Division of Fluid Dynamics, the Lars Onsager Prize of the APS, and the Dirac Medal of the Abdus Salam International Centre for Theoretical Physics. Kraichnan returned to academia in 2003 when he was installed as Homewood Professor of The Johns Hopkins University. Unfortunately, Bob was already quite ill and could not leave Santa Fe. Until near death, however, he was able to pursue research in the quantum measurement problem, a subject of long-standing interest to him. In addition to his achievements in physics, Kraichnan enjoyed classical music and was an accomplished violinist. Bob was also, in better days, an avid hiker. He took long walks daily, thinking deeply about science as he hiked. Much of his best work was done in his head while walking the hills and woods of New Hampshire and, later, the mountains and canyons of New Mexico. Kraichnan is survived by his wife, artist and photographer Judy Moore-Kraichnan, and by his former wife Carol Gebhardt, their son John Kraichnan, and granddaughter Sasha Kraichnan.

With the passing of Kraichnan, the physics community has lost a deeply original theorist. He was a unique and solitary thinker, but never isolated. Throughout his career, Bob took special interest in mentoring new researchers and was extraordinarily generous in sharing his own ideas. His many colleagues and friends feel sorrow, remembering his warm and kindly presence and his penetrating insights. We'll miss him very much.

Shiyi Chen (Johns Hopkins)
Gregory Falkovich (Weizmann Institute)
Uriel Frisch (Nice)
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