Obituary

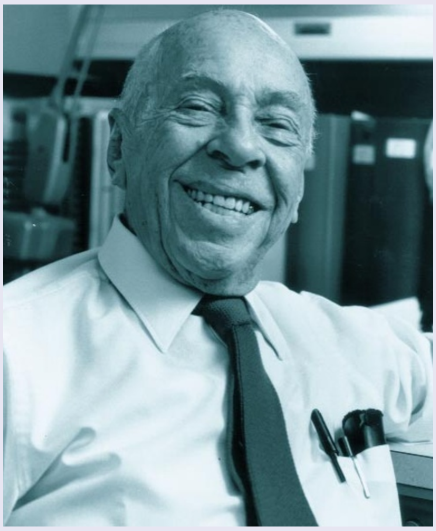
Ugo Fano (1912–2001)

Ugo Fano was a master at understanding how radiation interacts with matter. His work set the agenda for much of modern atomic physics, and had a broad sweep across fields as disparate as molecular biology and high-energy physics. His passing deprives us of a living link to the golden age of quantum mechanics, and to the "boys of the Via Panisperna" — Enrico Fermi's remarkable school of physics.

A member of a wealthy Italian Jewish family, Fano was named after his grandfather, who served under Garibaldi in the war for Italian independence. His father, Gino, was a professor of geometry at the University of Turin, and his childhood was spent in a privileged social milieu that was shaken by the First World War, and shattered by the Second. A story well known to Fano's colleagues recounts his first encounter at the age of 12 with Fermi: hiking along a mountain trail, Fano and his father were overtaken by a group of scientists from Rome. Pointing out a young man in the group, his father said: "That man is expected to go far in life. His name is Fermi."

When Fano graduated from the University of Turin, he joined Fermi's group in Rome at the age of 22. He soon made his most widely known contribution to science: an explanation of the asymmetric peaks seen in the spectra of radiation absorbed by atoms. This work was motivated by the spectral profiles of noble gases observed by Hans Beutler, but its results have found pervasive use. First published in *Nuovo Cimento* in 1935, the theory is best known in the extended form that Fano published in *Physical Review* (124, 1866–1878; 1961), which is still among that journal's most-cited papers. Its simple 'Fano profile' formula, which predicts the shape of spectral lines, has been a workhorse of nuclear, atomic, molecular and condensed-matter physics. This work bears Fano's distinctive signature, evocative of Fermi's: complex physical phenomena are encapsulated in a few key parameters, which can be calculated from first principles.

The rise of fascism in Italy was at first regarded by Fano's family as a matter of national embarrassment rather than as a direct personal threat. In 1936, Fano even joined Werner Heisenberg's group in Leipzig, where, by his own account, he was treated as an Italian rather than as a Jew. But after his return to Rome in 1938, the Italian government accelerated its own descent into anti-Semitic madness. His family's situation became untenable. After marrying Camilla Lattes in 1939, Fano went in exile to the United States, where he subsequently became a citizen.



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Outstanding interpreter of how radiation interacts with atoms and cells

His first paid job in America was in Milislav Demerec's group at the Carnegie Institute's Department of Genetics in Cold Spring Harbor. During his last days in Rome, Fano had been encouraged by Fermi to take up the study of biophysics from a fundamental perspective. The potent effects of X-rays on genetic materials suggested that radiation biology might identify the microscopic origin of the gene, a philosophy championed by Max Delbrück. Although trained as a theorist, Fano began studying the effects of X-rays on the eggs of the fruitfly *Drosophila melanogaster*, and, with Demerec, he performed the first isolation of *Escherichia coli* B.

Although Fano was soon drawn off to war work at the Aberdeen Proving Ground in Maryland, he derived a signal lesson from his forays into experimental biology. He realized that the effects of radiation on cells could not be encapsulated in a simple model of just the primary interaction. The energetic electrons produced by X-ray absorption initiate secondary reactions, and the ultimate effects of X-rays are determined by the dispersion of this energy in the material. Fano thus began a systematic study of the 'degradation' of energetic radiation in matter. This required an understanding of radiative and electron interactions over a wide range of energies, and lasted for the rest of his scientific career.

After the war, Fano joined the staff of the National Bureau of Standards (NBS) in Washington, where he remained until 1966. He is thought to be the first 'pure' theoretical physicist hired by the NBS, and while there he made definitive contributions to the theory of spectral line shapes, the stopping power of charged particles, and the quantum mechanics of many-particle systems. His research group's inclusion of women and African Americans would be noteworthy even by today's standards, but in 1950s Washington it also had to contend with racial segregation of public facilities.

Fano was noted for his close and demanding interaction with experimental groups. In particular, he was a central figure in the NBS 'resonance era' of the early 1960s, during which novel, highly excited, atomic states were revealed in synchrotron radiation and electron scattering experiments. Fano's analysis of the helium photoabsorption spectrum pointed to the existence of a correlated mode of two-electron excitation, which became a touchstone of his subsequent work.

Taking up an academic career at the University of Chicago in 1966, Fano established a school of atomic and molecular physics that addressed the blossoming experimental issues of that era, in particular those presented by the advent of laser spectroscopy. A number of now well-known effects are commonly identified by the adjective 'Fano', ranging from the production of spin-polarized electrons, to the excitation of deeply bound electrons in atomic collisions. Fano consistently applied his energies to the solution of great problems, and led his research group by personal inspiration.

Details of Fano's accomplishments can be found in a forthcoming issue of *Physics Essays*, edited by Mitio Inokuti and Ravi Rau. He is survived by his wife, Camilla Lattes Fano; daughters Mary Fano Giacomoni and Virginia Fano Ghattas; four grandchildren, and a brother, Robert Fano. His many students and colleagues strive to emulate his approach to physics.

Charles W. Clark

Charles W. Clark is in the Electron and Optical Physics Division, National Institute of Standards and Technology, Gaithersburg, Maryland 20899-8410, USA.
e-mail: charles.clark@nist.gov