

Ward's early work considered the effects of gauge invariance in electrodynamics and led to the formulation of a very general identity that relates the electron self-energy to the way electrons interact with photons; this Ward identity has been generalized somewhat, but remains an important theorem in the renormalization of quantum electrodynamics. Subsequently, in the early 1960s, he collaborated with Abdus Salam in working on

the connections between the weak, electromagnetic and strong interactions; his contributions were fundamental to the subsequent development of unified field theories. He has also been a source of many innovative ideas in other branches of physics, particularly in statistical physics—in the 1950s, for example, he collaborated with Mark Kac on a combinatorial approach to the two-dimensional Ising model.

obituaries

Felix Bloch

Felix Bloch died in Zurich on 10 September 1983 at age 77. He had been working and thinking of physics virtually up to the last day of his life. With his passing went one of the great physicists of the twentieth century.

Bloch was born in Zurich on 23 October 1905. His father urged him to study engineering, and after graduation from secondary school, he entered the Federal Institute of Technology in Zurich with the intention of pursuing such a career. His interests, however, really lay in theoretical directions, and physics and mathematics attracted him much more than did engineering. After a year he transferred to the Institute's division of mathematics and physics. There could hardly have been a better time, for during those years, 1924 to 1927, modern quantum theory emerged in such splendor. In the early part of this climactic period, Louis de Broglie, Werner Heisenberg, P. A. M. Dirac, Erwin Schrödinger, Samuel Goudsmit, George Uhlenbeck, and, a little earlier, Wolfgang Pauli, all made their great contributions to quantum physics.

Peter Debye, with whom Bloch studied at the Institute, suggested that he do his thesis work at Leipzig, where Heisenberg would soon join the faculty. In this way Bloch became Heisenberg's first graduate student. Under Heisenberg's tutelage he attacked the problem of the conductivity of metals and succeeded in his PhD thesis in finding the solution of the quantum theory of metals. This led in turn to the modern quantum theory of solids and eventually to modern radio, television, computers, and the electronic logic behind modern experimentation in virtually all fields of science.

Bloch returned to Zurich as Pauli's assistant in 1928 and worked on the theory of superconductivity. In the next year he became a Lorentz fellow in Holland and worked with both Hendrik Kramers and Adriaan Fokker. During this period he demonstrated that his thesis work could be successfully ex-



BLOCH

tended to the theory of electrical resistance, in agreement with experimental results. Moving again to Leipzig in 1930 with Heisenberg, Bloch worked on ferromagnetism and established the nature of the boundaries between domains, which have subsequently been known as "Bloch walls."

Bloch left Leipzig to join Niels Bohr's institute in Copenhagen. One result of his visit was that he became a lifelong friend of Bohr, subsequently visiting Bohr many times in Copenhagen. There he also worked on his famous contribution to the theory of the stopping of charged particles in matter. Again returning to Leipzig in 1932, he became Privat-dozent. When Hitler came to power in 1933, Bloch left Leipzig for his native Zurich. He spent some time as a Rockefeller fellow in Rome, and then, along with many others, left Europe in 1934.

In 1934 Bloch joined the department of physics at Stanford University. Bringing a new kind of physics to Stanford, he started to do neutron studies there. By 1936 he obtained experimental results on the magnetic scattering of neutrons. This familiarity with nuclear physics and his experi-

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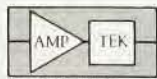
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mental achievements on the magnetic moment of the neutron that he and Luis Alvarez accomplished in 1939 at Berkeley eventually led to his discovery of nuclear induction. For this work, in which he collaborated with William W. Hansen and Martin Packard, Bloch was awarded the Nobel prize in physics for 1952 jointly with Edward Purcell, who had worked separately with Henry Torrey and Robert Pound. The discovery of nuclear induction became the foundation of new fields in physics, chemistry, biology, physiology and medicine. Indeed, the recent successes of magnetic resonance imaging in diagnostic medicine surely rival the tremendous advance brought about by Wilhelm Roentgen's discovery of x rays.

During the second world war, Bloch worked briefly at Los Alamos and at length in Frederick Terman's Radio Research Laboratory at Harvard on antiradar work. In 1945 Bloch returned to teaching and research at Stanford, where he continued his studies of nuclear induction and, with Leonard Schiff, built a great physics department.

In 1954 Bloch became the first director of CERN, newly formed, in Geneva and formulated and implemented its early scientific policies. Recognizing that his administrative duties prevented him from doing physics, he returned to Stanford a year later. Another sign of the wide appreciation of his accomplishments came in 1965: his presidency of The American Physical Society.

Bloch loved nature, particularly mountains. Fond of skiing, even in his later years he could be seen enjoying the slopes in his old ski suit. He also played the piano well and with tremendous satisfaction. Despite the extraordinary gifts that Bloch gave to the world, he remained modest, but not quietly modest, for he held strong opinions and was usually outspoken in expressing them. No one had any doubt about what Bloch was saying or where he stood on any issue. He enjoyed a good intellectual fight and together with his colleagues at Stanford often produced many sparks.

Felix and Lore Misch were married in 1940 after having met in the previous year at an American Physical Society meeting. Lore also holds a PhD degree in physics and worked in x-ray crystallography.

I was privileged to know Felix Bloch for some 34 years, in which I learned much from him, not only in physics, but also about all the best things in human companionship. I know that I speak for many others as well, and we are all going to miss him more than we know.

ROBERT HOFSTADTER
Stanford University

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