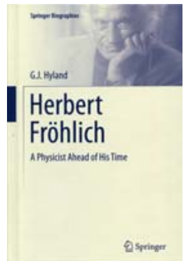

Herbert Fröhlich

A Physicist Ahead of His Time

Gerard Hyland

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There is no better indication of the respect that Herbert Fröhlich commanded in the physics community than the fact that after Fröhlich's death in 1991, 86-year-old Nevill Mott undertook to write an extensive account of his life and scientific accomplishments. Mott and Fröhlich had been colleagues at Bristol University in the UK from 1935 until 1948 and had collaborated on a 1939 paper concerning electrons in polar crystals—the paper that initiated Fröhlich's seminal work on polarons.

Mott's biographical essay about Fröhlich was published in the November 1992 *Biographical Memoirs of Fellows of the Royal Society*. In the essay's acknowledgment, Mott noted that Fröhlich's last PhD student, Gerard Hyland, was "responsible for part of the section on nuclear forces and for the list of publications." Hyland's new scientific biography, *Herbert Fröhlich: A Physicist Ahead of His Time*, takes off from Mott's memoir. Hyland has greatly expanded on the earlier work, drawing extensively on his own interactions and interviews with Fröhlich and on interviews with Fröhlich's widow and brother.

Fröhlich was born in 1905 in Rexingen, Germany, a small village in the Black Forest. He was the second of three children, a year younger than his sister Betty, who as a young woman emigrated to Palestine, and 10 years older than his brother Albrecht, who became a mathematician and a Fellow of the Royal Society. Fröhlich moved with his family to Munich just before he turned two. It was there that he first developed an interest in science.

Munich was also where his autonomy and independence manifested itself: He dropped out of high school when his stimulating and erudite mathematics teacher was replaced by a pedestrian one. But when he read that designing and building radios required a knowledge of advanced mathematics, he enrolled in a technical secondary school, where he decided to study experimental physics.

After passing his *Abitur* (matriculation examination) in 1927, Fröhlich enrolled at Munich University. His goal was to complete his doctorate under experimental physicist Wilhelm Wien. But Wien soon died, and Fröhlich decided to become a theoretical physicist instead. He attended lectures by Arnold Sommerfeld and impressed him. Sommerfeld allowed Fröhlich to enroll in his seminar and soon after asked him to supervise the problem session attached to his lectures. In 1930, just three years after he enrolled, Fröhlich completed his doctoral degree: His thesis, supervised by Sommerfeld and Gregor Wentzel, was on the photoelectric effect in metals.

Fröhlich moved to Freiburg University to work with Gustav Mie. However, that appointment was terminated in 1933 when Adolf Hitler enacted his racial laws. Fröhlich then moved to the Ioffe Physical-Technical Institute in Leningrad, USSR. He was very productive there and wrote a textbook on electrons in metals. By 1935 he was on the move yet again—this time forced to escape the country ahead of Joseph Stalin's Great Purge.

With the money he had earned in Leningrad, Fröhlich bought a railroad ticket to attend a conference on electrons in metals that Arthur Tyndall and Mott had organized in Bristol. Tyndall, who was the chair of the physics department at Bristol University, offered Fröhlich a stipend to move there. At the time, Bristol's physics department boasted an outstanding faculty, including Mott, and hosted a group of distinguished emigrants from Germany, including Walter Heitler, Heinz London, Klaus Fuchs, and Kurt Hoselitz.

In 1943 Fröhlich was given an academic appointment in the department. He collaborated with Heitler and Nicholas Kemmer in work on meson theory and nuclear forces and with Mott and others in work on solid-state physics. At Bristol, Fröhlich also formulated microscopic-level explanations of the macroscopic properties of dielectrics and, in particular, the breakdown of electric conduction in dielectrics. That work led to his book, *Theory of Dielectrics* (Clarendon Press, 1949).

In 1948 James Chadwick invited Fröhlich to the University of Liverpool. As a condition for acceptance, Fröhlich asked to be the head of an independent research department of theoretical physics and to be free of formal teaching responsibilities; his demands were met. At Liverpool Fröhlich made seminal contributions that helped solve the problem of superconductivity, which had not been solved with nonrelativistic quantum mechanics.

Fröhlich recognized that the electron–phonon interaction in a metal could give rise to an attractive force between pairs of electrons near the Fermi energy and that the electron–phonon system could have a state with lower energy than the one described by the Bloch theory. That would be the superconducting state, which existed only below a critical transition temperature. Fröhlich calculated that temperature and found that it depended on the isotopic mass of the metal concerned. His prediction was later experimentally confirmed.

However, Fröhlich's insight could not account for the existence of the superconducting gap. That explanation was obtained in 1956 by John Bardeen, Leon Cooper, and J. Robert Schrieffer; they obtained the ground state of the Hamiltonian provided by Fröhlich. Later, at Liverpool, Fröhlich worked on biological problems and, in particular, on the connection between a cell's energy storage and a possible long-range coherence among the molecules in the cell.

Hyland's biography captures all of the work summarized above and more. It is a valuable technical exposition of Fröhlich's oeuvre—not only his contributions to physics, but also his contributions to theoretical biology and his reflections on the relationship between mathematics and physics and between microscopic and macroscopic descriptions. Hyland must have invested a huge amount of work on his book; it is a labor of love.

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