Felix Bloch (1905–1983)

Felix Bloch
Photo Courtesy [1]

Felix Bloch was born in Zürich, Switzerland, on 23rd October 1905, to Jewish parents, Gustav and Agnes Bloch. The year he was born, Albert Einstein published three seminal works: (Brownian Motion, Special Theory of Relativity and Photo Electric Effect), also from Zürich. Young Felix (Felix means 'lucky') [2], had his schooling in the local 'gymnasium' (which are very good schools in Switzerland) and then went on to study in the famous ETH (Eidgenössische Technische Hochschule) in Zürich, first for doing 'Engineering' but later switched to 'Physics' [2]. This was the decade of the 1920's, the hay days of 'Quantum Mechanics', in Europe and especially in Copenhagen and Zürich. In Zürich, he came in contact with the likes of Peter Debye, Hermann Weyl, Erwin Schrödinger, John von Newmann, and Wolfgang Pauli; in Copenhagen with Niels Bohr and in Rome with Enrico Fermi. He ended up doing his PhD under the supervision of Werner Heisenberg in Leipzig. Both the student and the supervisor were in their 20's, separated by 5–6 years in age. His doctoral thesis (1928) established the quantum theory of solids, using *Bloch waves*. Soon after, with Grueneisen, he gave the first comprehensive theory of the temperature dependent resistivity of metals, deriving a formula named after both of them. The transition separating two magnetic domains with different orientations was analyzed by him and is known as a 'Bloch wall'. Later, he joined the university of Leipzig as a Lecturer.

In 1933, when Hitler came to power, Felix left Germany and decided to move to USA, landing up on the West Coast, in the University of Stanford, where he stayed for the rest of his academic life. He made contacts with University of Berkeley. At the time, Robert Oppenheimer was teaching at Berkeley, and since Bloch had already been acquainted with him, they saw each other constantly. They set up a joint seminar on theoretical physics, meeting alternately in Berkeley or Stanford and occasionally elsewhere on the West Coast. Because of Felix's reputation and presence at Stanford, prominent physicists visited him, most often in the summer, and stayed for a few weeks or longer. Among these many visitors were Gamow, Fermi, Rabi, Bethe, Weisskopf, Lamb, Nordsieck, Schein, and Bohr [2].

In 1939, he became a naturalized citizen of the United States. Also in 1939, at a meeting of the American Physical Society, in Washington DC, he met Lora Misch, a young immigrant from Europe, also a physics PhD from Göttingen, working in MIT. Felix and Lora were married in 1940 (they had 3 sons and a daughter, and eleven grandchildren, all of whom grew up in USA) [2].

During the Second World War, Felix worked on atomic energy at Los Alamos, NM, and radar counter measures at Harvard university. After the war, he returned to Stanford and, in 1945, with Hansen and Packard [3,4], worked on the detention of nuclear magnetic resonance in bulk matter using 'nuclear induction experiment', a work for which he shared the 1952 Nobel Prize in Physics with E M Purcell of Harvard university who had also just observed NMR in bulk matter via 'direct absorption of the RF'. Incidentally, it was the *first* Nobel Prize to be awarded to a Professor from Stanford University. Soon after the detection of the NMR signal, Bloch wanted to measure the gyro-magnetic-ratio of various nuclei "accurately". In this attempt, he got frustrated when his student S S Dharmatti, put ethyl alcohol in the NMR sample tube and observed three signals, discovering 'chemical shifts' in protons [5]. It then immediately became obvious that this technique would lead to large-scale applications of NMR to chemistry, and indeed in later years it did revolutionize the practice of chemistry. A romantic, but perhaps-not-true story is that on seeing the three lines of ethyl alcohol, Bloch is rumored to have said, "You chemists can have the technique and I am moving to solid-state physics". He, nevertheless, did not leave his love for NMR. He had earlier given the 'phenomenological' Bloch equations for describing T_1 and T_2, relaxation times of NMR [4]. These Bloch equations had a great impact on the teaching of NMR to new entrants. A complete solution of these three coupled equations, in presence of an off-resonant RF field, were provided by Torry in 1949 [6]. These solutions were the 'last word', till recently [7]. Bloch, along with Wangsness, later provided a detailed theory of NMR relaxation in coupled spin-systems in a series of papers in 1953, 1956 and 1957 [8].

Niels Bohr continued to have a strong influence on Felix and suggested that he take on the job of Director General of CERN, which was just being organized. Although Felix had many doubts about the operation of big accelerators, he accepted the appointment in 1954, which, of course, was largely administrative. Even so, when he went to Geneva, he took along Stanford equipment, and he and two colleagues, Jim Arnold and Wes Anderson, continued nuclear induction experiments. As Felix had predicted, he didn't care for administrative work, and after a trial period of one year, he returned to Stanford, but not before leaving a great and positive influence at CERN [2]. CERN is, of course, famous for the recent discovery of the Higgs particle. Felix was elected president of the American Physical Society in 1965.

Felix Bloch, ironically, died while on a short visit to Zürich in 1983, due to a heart attack. He is buried in Zürich, the city of his birth.

Suggested Reading

[1] Wikipedia (https://en.wikipedia.org/wiki/Felix_Bloch)

[2] *A Biographical Memoir of Felix Bloch* by Robert Hofstadter: Copyright 1994 , National Academy of Sciences, Washington DC.

[3] F Bloch, W W Hansen and Martin Packard, The nuclear induction experiment, *Phys. Rev*., Vol.70, p.474, 1946.

[4] F Bloch, W W Hansen and Martin Packard, Nuclear induction, *Phys. Rev*., Vol.70, p.460, 1946.

[5] J T Arnold, S S Dharmatti and M E Packard, Chemical effects on nuclear induction signals from organic compounds, *J. Chem. Phys*., Vol.19, p.507, 1951.

[6] H C Torry, Transient nutations in nuclear magnetic resonance, *Phys. Rev*., Vol.76, p.1059, 1949.

[7] P K Madhu and Anil Kumar, Bloch equations revisited: A new analytical solution of generalized Bloch equations, *Concepts in Magnetic Resonance*, Vol.9, pp.1–12, 1997.

[8] (a) R K Wangsness and F Bloch, The dynamical theory of nuclear induction, *Phys. Rev*., Vol.89, p.728, 1953. (b) F Bloch, Dynamical theory of nuclear induction II, *Phys. Rev*., Vol.102, p.104, 1956. (c) F Bloch, Generalized theory of relaxation, *Phys. Rev.,* Vol.105, p.12069, 1957.

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