BOOKS: HISTORY OF SCIENCE

Quantum Physics With an Eastern Eye

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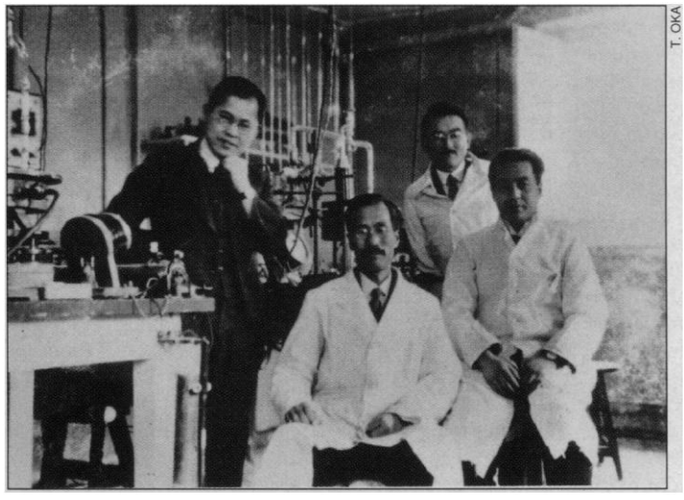
The Story of Spin. SIN-ITIRO TOMONAGA. Translated from the Japanese edition (1974) by Takeshi Oka. University of Chicago Press, Chicago, 1997. xii, 258 pp., illus. $50 or £39.95. ISBN 0-226-80793-2.

The Story of Spin—a translation of Sin-itiro Tomonaga's 1974 book *Spin wa meguru* by Takeshi Oka, professor of chemistry, astronomy, and astrophysics at the University of Chicago—focuses on the developments in quantum physics from 1920 to 1940. The intrinsic spin of the electron and other particles is the common thread that permits the author to describe the amazing outburst of creative energy that began in the mid-1920s and extended to the mid-1930s and beyond, as the "new quantum mechanics" and "second-quantized" fields were invented and deployed to address every aspect of atomic, molecular, and nuclear physics.

All the well-known protagonists—Bohr, Dirac, Heisenberg, Pauli, and many more—make an appearance. Tomonaga, who completed his undergraduate degree in Kyoto in 1929, listened to lectures by many of the great physicists, visited Germany in the late 1930s, and heard—and, in later years, read—accounts of crucial steps in the story. The book is thus rich in anecdotes, often nicely colored by the author's observations or conjectures as to the thinking and attitudes of those involved.

The book's 12 chapters are called lectures, although the length and detail of most of these implies a remarkable attention span for Japanese students. The informal style, with occasional colloquialisms (such as "see you later, alligator," making one wonder what the literal translation of the Japanese is), is consistent with lectures as the original format. The translator believes the book to be "readable not only for advanced students of physics but also for general science students." I beg to disagree. Dirac matrices, the difference between the relativistic transformation properties of tensors and spinors, and Pauli's spin-statistics theorem are not topics accessible to general science students, at least not in the United States. Right from the start, the author assumes a knowledge of nonrelativistic quantum mechanics, simple matrices, and Bose and Fermi statistics, as well as classical mechanics of charged particles in electromagnetic fields.

The thread of electron spin is followed from the multiplet structure of atomic states to Pauli's ad hoc introduction of a new classically indescribable degree of freedom, to Uhlenbeck and Goudsmit's concept of a spinning electron, to Thomas's brilliant resolution of the discrepancy between the Zeeman effect and spin-orbit splittings, to Pauli's nonrelativistic quantum theory with spin (with empirical *g* factor), to the culmination in Dirac's "acrobatics" (Pauli's word) of the Dirac equation, all told with great flair. Tomonaga believes that Pauli, the perfectionist, was crushed by Dirac's triumph in explaining spin and resolving all the problems of atomic fine structure solely from the demand of relativistic invariance. He thinks that the 1932 Pauli-Weisskopf work on quantization of the bosonic fields was motivated, in large part, by an attempt to disprove Dirac's assertion that only his equation of spin-$^1/_2$ particles described nature.



T. OKA

Japanese physicists in Bohr's institute, 1926. (Left to right: Y. Nishina, S. Aoyama, T. Hori, and K. Kimura)

Atomic structure is not the only topic covered by the book. Heisenberg's introduction of the exchange energy of electron-electron interactions in atoms, the connection between spin and statistics, the development of quantum field theory, the discovery of the neutron, Heisenberg's concept of isospin and explanation of nuclear structure, and Yukawa's meson hypothesis are also featured. Some of the stories are well known, others not. I particularly enjoyed the account of the coming into being of electron spin, in which the story moves from Kronig to Pauli (categorical rejection of Kronig's idea) to Uhlenbeck and Goudsmit to Thomas and back to Pauli ("I now believe in the idea of the self-rotating electron"). The tale is indicative initially of what the postmodernists say is the sociology of science, but its ending shows the ultimate triumph of rationality in the face of objective reality.

Another delightful tale that is less well known is the story of the discovery in 1927 of the proton's spin from molecular spectroscopy. The conflict between the conclusions drawn from the specific heat of hydrogen by a German (Hund) and the precise molecular spectroscopy data of a Japanese (Hori) is reconciled by an insight from an American (Dennison): The spin of the proton is thus established, as are *ortho*- and *para*-hydrogen as two almost distinct species of H_2.

The reader may gather that I enjoyed this book. I was also put off by it. The anecdotal style is light and informal. However, the style when dealing with theoretical development is often pedestrian and turgid. Generally, physical meaning is discussed only at the end of a long formal development. Several chapters will be only of interest to (and understandable by) physicists with fairly advanced training. Nonetheless, Tomonaga's book is a valuable account of a glorious period in the history of physics by one of the generation just behind the pioneers. In the last lecture, he gives us a fascinating glimpse of physics in Japan in the 1920s and 1930s and of his own beginnings as a theoretical physicist. Only here does he make a glancing mention of his later work on quantum electrodynamics for which he shared the 1965 Nobel Prize for Physics with Feynman and Schwinger. The unevenness of which I complain is addressed by Tomonaga in the last sentence of his epilogue: "This book has grown while I indulged my tastes without worrying too much about the readers." Fair enough. I recommend the book to physicists and chemists, but also to that elusive "scientifically literate" reader—who can skip the dry mathematical passages and enjoy the nuggets.

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