"The Story of Spin"

From Spectroscopy to Relativistic Quantum Mechanics

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The Story of Spin
Sin Itiro Tomonaga
Translated by Takeshi Oka
The University of Chicago Press, 1997

After Hideki Yukawa won the Physics Nobel Prize in 1949, his class-fellow Sin-Itiro Tomonaga was the next Japanese theoretical physicist to be so honoured. He shared the 1965 Prize with Richard Feynman and Julian Schwinger for their renormalisation theory of quantum electrodynamics. Apart from being a master theoretical physicist, Tomonaga was also a highly gifted writer (and culturally very refined and sensitive in a deeply Japanese way); his two books on quantum mechanics are masterpieces deserving much greater attention than they seem to have received.

In *The Story of Spin*, Tomonaga describes many key developments in microscopic physics in the crucial period from the early 1920's to about 1940 generally revolving around the concept of spin. It is based on a series of twelve lectures delivered over several months in the early 1970's, and put together in the form of a book in Japanese in 1974. Tomonaga begins with the struggles to understand spectroscopic data and the detailed ways in which spectral lines split in magnetic fields, and how the idea of a new degree of freedom for the electron – its spin – slowly evolved. Many now forgotten historical details are carefully recalled. Around this time quantum mechanics too was about to appear on the scene, and the stories get intertwined. We read about the state vector concept in quantum mechanics, Dirac's 'majestic transformation theory', the Pauli description of spin and his nonrelativistic equation, and then – like a bolt from the blue – the emergence of the Dirac equation.

Tomonaga spent two years in Leipzig in the late thirties working with Heisenberg. It is understandable (and in any case it must be so!) that Heisenberg's work in many areas is very carefully discussed, giving a lot of attention to his motivations and method of thinking. We learn about his work on ferromagnetism, the exchange interaction, the basic ideas of the nuclear force, isotopic spin and so on. The Dirac idea of second quantisation, and the Pauli theorem of 1940 on the relation between spin and statistics, get especially thorough treatment. The concept of spinors, and the way they behave under rotations, is also beautifully explained.

Tomonaga traces the deep connections and motivations linking important events and discoveries which we today tend to view as isolated advances – Bohr's idea of nonconservation of energy in beta decay and inapplicability of quantum mechanics within the nucleus; Pauli's neutrino idea and Fermi's use of it; Heisenberg's theory of the exchange

force between protons and neutrons and the later Yukawa theory of the meson, and so on. Only a master in the subject can achieve such a perspective and write about it so well. There is also a good deal of mathematical treatment of the Lorentz group, in connection especially with the work of L H Thomas.

Probably the best chapters are the third, on the Pauli and Dirac equations for the electron; the eighth, sketching Pauli's derivation of the spin-statistics connection; the ninth, on the amazing discoveries in 1932 and how they influenced the future of physics; and the tenth, largely concerned with Heisenberg's inauguration of nuclear physics within the basic quantum mechanical formalism. Tomonaga's explanations are very leisurely and lucid; and when mathematical he stops at just the right place! Some of the material is quite demanding, calling for a high degree of maturity from the reader. His assessments of the characters of the giants of the field and their attitudes towards one another are charming, a sample being: "Dirac's acrobatics, Pauli's frontal assault, and Heisenberg's analogising: each is uniquely characteristic of its practitioner so that we are never bored following their work". Anecdotes and vignettes abound.

This is a very sophisticated, highly personal account of major developments in physics, and those who brought them about, largely to do with the spin of elementary particles but covering a lot of ground in related areas. It bears much and careful re-reading to fully extract all the meanings and linkages, that only a gifted raconteur like Tomonaga can show us.

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Naturalists in a Nutshell: 90 Minute Biographies of Eminent Scientists

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Mendel, Curie, Darwin, Faraday, Galileo, Newton, Halley and Einstein
By John and Mary Gribbin
Universities Press, Each Rs. 45

Though scientific principles are universal and transcend personal prejudices and subjective points of view, our understanding of them was made possible because of contributions of great scientific minds. Part of the charm of appreciating monumental scientific discoveries is in knowing about the lives and times of the men and women who made them possible and the circumstances that led them to rise above the rest. Well-written biographies of great scientists are always a source of inspiration and enlightenment, particularly for those who are beginning their pursuit of scientific discoveries. The biography series penned by John and Mary