Sin-itiro Tomonaga: Impressions and Reminiscences

Sin-itiro Tomonaga: Life of a Japanese Physicist

Edited by Makinosuke Matsui
Translated by C. Fujimoto and T. Sano
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Reviewed by Silvan S. Schweber

After Sin-itiro Tomonaga's death in 1979, Makinosuke Matsui, a close friend, sought out people who had known Tomonaga and asked them for impressions and reminiscences that would "illustrate the course which he took in life." The result is *Sin-itiro Tomonaga: Life of a Japanese Physicist*. The book is not a biography, nor does it contain a technical exposition of Tomonaga's scientific works. But it is a singularly absorbing collection of remembrances that highlights the life of a remarkable human being.

Tomonaga was born in 1906. He grew up in Kyoto, where his father was a professor of philosophy at the university. His father, a close friend of the chief priest of the head temple of the Tendai Buddhist sect, was invited to live in a large house on the temple grounds. The house became filled with books, which nurtured the young Sin-itiro's passionate curiosity, and the temple grounds helped nourish his intense communion with both nature and Japanese culture.

One of the striking features of Matsui's book is that it makes palpably clear how powerful a mold Japanese culture is—and how profoundly meaningful that culture and its traditions were to Tomonaga. It inculcated him with a deep sense of responsibility to the nation, which led him to accept the burdens of academic and governmental administrative posts after 1951. It expressed itself in his lifelong friendships with classmates from middle and high school and from Kyoto University and with colleagues from RIKEN (the Institute of Physical and Chemical Research, outside Tokyo), friendships that were renewed whenever possible by exchanging memories over sake. Late in life, Tomonaga was quoted as saying: "What I am today I owe entirely to sake. I was not blessed with physical and mental strength as a child, but sake cured completely my inferiority complex." Perhaps more accurately, sake was the emollient that allowed the formalities of Japanese culture to be overcome and made possible the strong bonds Tomonaga formed with his friends. Tradition shaped the character of his marriage and helped define the special relationship he had with his wife, Ryoko, and she with him. He was fond of saying that Ryoko was his "guardian." The poem she wrote after his death, the final entry of the volume, is one of the most moving elegies I have ever read.

SILVAN S. SCHWEBER *is a professor of physics and of the history of ideas at Brandeis University, in Waltham, Massachusetts. He is presently writing a biography of Hans A. Bethe.*

SIN-ITIRO TOMONAGA– "If I could believe there were/Two men like you in Japan,/I would never grieve." (Photo courtesy of AIP Niels Bohr Library.)

The earliest of the recollections in the book is of a reunion between Tomonaga and his kindergarten teacher. Even though the exchange took place some 60 years after Tomonaga had attended the school, and even though the teacher had taught over a thousand children in her 40 years as a kindergarten teacher, she remembered him very distinctly as a thin, bony, extremely quiet little boy who was always on the verge of tears. He in turn had a vivid memory of the long row of camellias along the playground fence and the flower bed at the end of it.

By middle school, the boy knew that he wanted to become a scientist, perhaps a biologist. Einstein's visit to Japan in 1922 resulted in extensive accounts of the theory of special and general relativity in the popular press, which Tomonaga found unsatisfactory. Being "a cocky middle school student," he turned to a book by Jun Ishihara and became fascinated by the four-dimensional world and by non-Euclidean geometry. He decided to study physics.

A lecture in Kyoto by Yoshio Nishina in 1931 was a turning point in Tomonaga's life. After working closely with Niels Bohr and Oskar Klein in Copenhagen during the 1920s, Nishina had come back to Japan, where he founded a cosmic-ray and nuclear-physics laboratory at RIKEN. Nishina was deeply impressed by the insight and incisiveness of Tomonaga's questions following the lecture and invited the young graduate student to come work with him. Nishina became Tomonaga's mentor and a father figure for him. Tomonaga throve in the stimulating atmosphere of Nishina's laboratory and assumed the position of house theorist for the group. In 1937 Tomonaga went to Leipzig to work with Werner Heisenberg, and upon his return to Japan in 1939 he accepted a professorship at Bunrika (Liberal Arts and Science) University in Tokyo.

While engaged in wartime work on magnetrons and radar devices, Tomonaga in 1943 generalized Paul Dirac, Vladimir Fock and Boris Podolsky's many-time formalism and recast relativistic quantum field theories in an explicitly Lorentz-invariant form. In the ruins of Tokyo in the immediate post-World War II period, Tomonaga used this formalism to formulate the renormalizaton procedures, as did Hendrik Kramers, Hans Bethe, Julian Schwinger, Richard Feynman and Freeman Dyson, working on the other side of the world. This made it possible to isolate and discard in a consistent manner the divergences encountered in perturbation-theory calculations of quantum electrodynamics and thus to perform a fully relativistic calculation of the Lamb shift. For this work, Tomonaga shared the Nobel prize with Feynman and Schwinger in 1965.

Nishina died unexpectedly in January 1951, and Tomonaga took over many of his duties on governmental committees. Tomonaga's technical knowledge, sagacity and evenhandedness led inevitably to his being involved almost full-time in science policy. He served on many influential governmental committees, eventually becoming the president of the Science Council, and he was frequently appointed the official emissary to represent Japanese culture and science at international gatherings. He actively participated in the Pugwash Conferences until the end of his life.

Most of his time after 1951 was taken up by administrative duties, including three terms as president of the Tokyo University of Education, and he welcomed his retirement in 1969. It gave him the leisure to give lectures, to write essays on a variety of subjects and to cultivate his friendships. At the time of his death, he had completed a manuscript that was published posthumously in two volumes with the title *What is Physics?*

A threnody from *Man'yoshu*, an anthology of 8th- and 9th-century Japanese poems, expresses the emotion shared by all who came in contact with Tomonaga during his mature years:

> If I could believe that there were
> Two men like you in Japan,
> I would never grieve.

The Nature of Space and Time

Stephen Hawking
and Roger Penrose
Princeton U. P., Princeton, N.J., 1996. 152 pp. $24.95 hc
ISBN 0-691-03791-4

The clash between Niels Bohr and Albert Einstein over the meaning of quantum theory greatly clarified some fundamental issues, but to this day it is widely felt that their differences have never been satisfactorily resolved. It seems most appropriate, then, for two leading physicists of the current era to carry on the debate, and who could be better qualified than Stephen Hawking and Roger Penrose? Arguably, the two most profound developments in general relativity since Einstein were the introduction of the global analysis of causal structure by Penrose and the discovery of black-hole thermodynamics and black-hole radiance by Hawking. Furthermore, both men are justly admired for the lucidity of their writings and lectures, and they disagree sharply on some fundamental questions.

The Nature of Space and Time is based on a Hawking–Penrose debate that took place in England, at the University of Cambridge, in the spring of 1994; the "debate" consisted of alternating lectures (three by each author) followed by a final joint discussion. The lectures revealed that there is much on which Hawking and Penrose agree. Both believe that black holes destroy information and hence undermine the foundations of quantum theory. Both argue that the origin of the second law of thermodynamics can be traced back to the extremely homogeneous conditions that reigned in the very early universe and that it is ultimately the task of quantum gravity to explain these initial conditions. They also seem to agree that general relativity, a beautiful and highly successful fundamental theory, sometimes fails to get the respect it deserves from the particle physicists.

Various points of disagreement are mentioned at least in passing. Hawking advocates the Euclidean path-integral approach to the fundamental issues of quantum gravity; Penrose is skeptical. Hawking offers the "no-boundary proposal" (rooted in the Euclidean formalism) to account for the initial conditions in the Big Bang; Penrose prefers the more phenomenological Weyl-curvature hypothesis. Hawking believes that the universe must be closed (as seems to be required by the no-boundary proposal); Penrose favors an open universe (which meshes more easily with his idea that quantum gravity should be formulated in terms of "twistors"). Hawking is an enthusiast of the inflationary-universe; Penrose is not.

There are two important issues over which the disagreements are more profound and more interesting. First, there is disagreement about the time-reversal invariance (or more precisely, *CPT* invariance) of the microscopic laws of nature. Hawking has a strong conviction that *CPT* is an inviolable symmetry. But Penrose believes that the quantum behavior of black holes shows otherwise; he argues that the laws of quantum gravity must make a fundamental distinction between past and future singularities. Further, they disagree about the measurement problem of quantum theory: Penrose insists that there must be a genuine physical mechanism underlying the "reduction of the state vector" in the measurement process, and he further proposes that quantum gravity plays an essential role in this reduction; Hawking rejects these ideas.

These are certainly fascinating questions, so it is rather disappointing that the authors do not flesh out their positions more fully. To understand Penrose's views clearly, I needed to reread his previous books, especially chapters 6–8 of *The Emperor's New Mind* (Oxford U. P., 1989) and chapter 6 of *Shadows of the Mind* (Oxford U. P., 1994). The key problem repeatedly stressed by Penrose in *The Nature of Space and Time* is that we never perceive macroscopic superpositions—the famous conundrum of Schrödinger's cat. This emphasis surprises me. While the modern theory of decoherence is surely incomplete—it is largely based on heuristic arguments and oversimplified models—I think that there is a plausible explanation, within conventional quantum theory, for the fact that superpositions of macroscopically distinct states decohere very rapidly. (See, for example, Wojciech H. Zurek's article in PHYSICS TODAY, Oct. 1991, p. 36.) Penrose thinks otherwise. There may be other more serious objections to the foundations of quantum theory, some of which are mentioned in Penrose's other books, but these receive scant attention here. Hawking, for his part, defends the status quo, but in so sketchy a manner as to provide little guidance for the perplexed.

I should not give the impression that this is a book about the measurement problem in quantum theory; the lectures largely address other issues: Hawking's three lectures concern global methods and singularity theorems; quantum black holes and information loss; and quantum cosmology, inflation and the origin of the anisotropy of the cosmic background radiation. These lectures are unapologetically mathematical, at an appropriate level for a graduate student in theoretical physics but quite beyond the grasp of the typical lay reader. Penrose's lectures on cosmic censorship, the measurement problem and twistors are less demanding than Hawking's (and about half as long), but they are also intended for a mathematically sophisticated audience. Advanced students and even some experts will appreciate, for example, Hawking's succinct summary of the ideas underlying