Sin-Itiro Tomonaga

Julian Schwinger

Richard Feynman

Tomonaga, Schwinger, and Feynman Awarded Nobel Prize for Physics

The 1965 Nobel prize for physics has been awarded to three theorists, Sin-Itiro Tomonaga of Tokyo, Julian Schwinger of Harvard, and Richard Feynman of the California Institute of Technology. The prize was given for their creation of the modern theory of quantum electrodynamics. This is the theory which brought order and harmony into the vast middle ground of physics, excluding gravitation on the one side and nuclear forces on the other, but including the laws of atomic structure, radiation, creation and annihilation of particles, solid-state physics, plasma physics, maser and laser technology, optical and microwave spectroscopy, electronics, and chemistry. Quantum electrodynamics unifies all these diverse phenomena into a small number of principles of great generality and elegance, weaving together special relativity with quantum mechanics in a seamless fabric. It is in a certain sense the most perfect and the most highly developed part of physics.

Since its completion in 1948, the theory has been tested by means of a succession of experiments of steadily increasing accuracy. For example, the magnetic moment of the electron was recently measured by Crane at the University of Michigan with an error of less than 1 part in 10 million. This was a beautiful and formidably difficult experiment, but unfortunately the result attracted little attention; it only proved that quantum electrodynamics was right to two more places of decimals.

Just this year there have been experimental indications of a possible deviation from the theory in the behavior of electron-positron pairs produced at energies of billions of volts. If confirmed, this deviation will by no means invalidate the theory, but will only show for the first time where the boundary lies between quantum electrodynamics and the world of high-energy particles. It is still one of the major mysteries of physics how quantum electrodynamics, a theory which deliberately excludes from consideration all particles except the well-known electron, positron, and photon, can give so amazingly accurate a representation of reality over so wide a range of conditions.

The three creators of the theory did their work independently and not simultaneously. Tomonaga kept alive in Japan during World War II a school of theoretical physics which was in some ways ahead of the rest of the world. In these conditions of total isolation he published his fundamental paper in Japanese in 1943. Schwinger and Feynman were meanwhile fully occupied with the development of radar and nuclear energy, respectively. When they returned to academic life after the war, their interest was aroused by a series of new experiments on the fine details of the hydrogen atom. The experiments had become possible as a result of the wartime development of microwave techniques, and were about a thousand times more accurate than the best prewar measurements. The new experiments made glaringly obvious the lack of a satisfactory theory of radiative processes, and so Schwinger and Feynman were led along different paths to invent such a theory. Each of them completed his work during the winter of 1947–48, just at the time the first English-language translations of the papers of Tomonaga and his students began to arrive from Japan. It was interesting to find that, although the new experiments had played a decisive role in the thinking of Schwinger and Feynman, Tomonaga had been able to reach an essentially identical insight on the basis of theoretical considerations alone.

The fact that the theory had three discoverers rather than one proved very fruitful for its further development. Each of the three brought a different viewpoint and a different style, and so the theory gained in breadth and richness. Tomonaga was most concerned with basic physical principles; his papers were simple, clear, and free from elaboration of detail. Schwinger was most concerned with the construction of a complete and massive mathematical formulation; his papers were monuments of formal ingenuity. An unkind critic once said: "Other people publish to show you how to do it, but Julian Schwinger publishes to show you that only he can do it." It was in fact Schwinger who was the first to hack his way through the mathematical jungle and arrive at a definite numerical value for the magnetic moment of the electron.

Feynman's approach was the most original of the three; he was willing to take nothing for granted, and so he was forced to reconstruct almost the whole of quantum mechanics and electrodynamics from his own point of view. He was concerned with deriving simple rules for the direct calculation of physically observable quantities. His invention of "Feynman graphs" and "Feynman integrals" made it easy to apply the theory to concrete problems. In the end, Feynman's rules of calculation have become standard tools of theoretical analysis, not only in quantum electrodynamics but in high-energy physics as a whole. And Feynman's insistence on discussing directly observable quantities led to the growth of the "S-matrix point of view," which now dominates current thinking about the fundamental particles and their interactions.

The theory which came to triumph in 1948 is not an easy one to describe in nontechnical language. It must be placed in the context of some earlier history. The pioneers of quantum mechanics—Dirac, Heisenberg, Pauli, and Fermi—had worked out the physical basis for quantum electrodynamics during the late 1920's. The basis consisted in a direct application of the methods of quantum mechanics to the Maxwell equations describing the electromagnetic field. The resulting theory seemed to give a qualitatively correct account of radiation processes, but it failed to give exact predictions. When pushed beyond the first approximation, it always gave infinite or meaningless answers. In the face of this situation, the physicists of the 1930's mostly looked for radical changes in the theory. It was generally believed that the "divergence difficulties" were symptoms of fundamental errors, and were only to be escaped by altering the theory drastically. So from 1935 to 1945 there was a succession of fruitless attempts to cure quantum electrodynamics of the divergence disease by methods of radical surgery.

Tomonaga, Schwinger, and Feynman rescued the theory without making any radical innovations. Their victory was a victory of conservatism. They kept the physical basis of the theory precisely as it had been laid down by Dirac, and only changed the mathematical superstructure. By polishing and refining with great skill the mathematical formalism, they were able to show that the theory does in fact give meaningful predictions for all observable quantities. The predictions are in all cases finite, unambiguous, and in agreement with experiment. The divergent and meaningless quantities are indeed present in the theory, but they appear in such a way that they automatically eliminate themselves from any quantity which is in principle observable. The exact correspondence between quantities which are unambiguously calculable and quantities which are observable becomes, in the end, the theory's most singular virtue.

The theory, as Tomonaga, Schwinger, and Feynman left it, has stood the test of time for 17 years. It describes only a part of physical reality, and it makes no claim to finality. But its success within its area of applicability has been so complete that it seems sure to survive, at least as a special limiting case, within any more-comprehensive theory that may come later to supersede it.

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Speaker Ban (I): North Carolina Law Stirs Unrest at University

Chapel Hill, N.C. Controversies over who shall be permitted to speak on university campuses are not unusual, and communists and other radicals of various hues often have been barred from campuses across the country. Sometimes a board of trustees has been the one to deny a university forum to speakers of dubious political coloration; in other instances, administrators, particularly at public institutions, have kept the radicals out for fear of incurring the displeasure of trustees or politicians. The "speaker ban" imposed more than 2 years ago by the General Assembly of North Carolina is believed to be unique, however. It has created severe strains between the University of North Carolina and the legislators. UNC officials say no other state has imposed so restrictive and inflexible a law. The speaker-ban statute, passed almost frivolously in the closing days of the 1963 session of the Assembly, without hearings and under suspension of the rules, proscribes not only "known communists" but persons who have pleaded the Fifth Amendment in loyalty investigations. UNC, a prophet in its region and perhaps the most distinguished of southern universities, has been warned by the Southern Association of Colleges and Schools that its accreditation is in danger because of the "political interference" in its affairs.

Paul F. Sharp, chancellor at Chapel Hill, has summed up the speaker ban's consequences: "Faculty morale has suffered, students are restless, administrators are harassed and distracted from essential duties, public controversy mounts, accreditation is threatened, professional organizations refuse to

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