AWARDS

Nobel Prizes 1965

Three theoretical physicists have been named by the Swedish Royal Academy to receive the 1965 Nobel Prize in physics in recognition of their fundamental work in quantum electrodynamics. The prize will be shared by Richard P. Feynman of the California Institute of Technology, Julian Schwinger of Harvard University, and Sin-itiro Tomonaga of the Tokyo University of Education.

The early development of quantum electrodynamics, the quantum

—Wide World

Sin-itiro Tomonaga

theory of the interaction of electrons and electromagnetic radiation, occurred during the late 1920's after its conception by P.A.M. Dirac. During its childhood the theory was able to describe many atomic processes—the emission and absorption of light by atoms, the Raman, Compton, and photoelectric effects, pair production, and the existence of photons as Bose-Einstein particles—but its growth was stunted by an attack of divergence difficulties. In the theory the vacuum is pictured as a complicated medium containing fluctuating zero-point electric fields and fluctuating electron pairs. In calculations made according to the standard recipes of quantum mechanics, these fluctuations seemed to give rise to infinite values for the electron energy and current.

In the late forties, three experiments made possible by wartime developments in microwave and magnetic resonance techniques opened the door for the theorists. Nafe, Nelson, and Rabi accurately measured the hydrogen hyperfine structure; then Foley and Kusch did the same for the fine structure. Both groups concluded that the electron magnetic moment was bigger than predicted by the Dirac theory. At about the same time, Lamb and Retherford found a splitting between the $^2S_{1/2}$ and $^2P_{1/2}$ states of hydrogen, whereas the Dirac theory predicted an exact degeneracy.

Meanwhile, Tomonaga had already published his fundamental article in Japan during the war, but physicists elsewhere didn't hear of his work until later. In the United States, Schwinger, working at Harvard, independently came up with a theory quite similar to Tomonaga's, and Feynman, at Cornell, developed a very different-looking formulation. Soon afterward, however, Freeman Dyson showed that Schwinger and Tomonaga's theory was equivalent to Feynman's; by integrating the differential equations of one theory Dyson got to the starting point of the other. Both theories disposed of the divergences and agreed beautifully with the experiments on the Lamb shift and anomalous magnetic moment.

In their reformulation, Feynman, Schwinger, and Tomonaga, got rid of the electron's intrinsic mass and charge, since these parameters are not measurable. Because the electron interacts with the vacuum fluctuations of the electromagnetic field, it has an extra bit of mass, and what gets measured is the sum of electromagnetic and mechanical mass. The electron also disturbs the fluctuating pair distribution; the disturbance causes a polarization of the vacuum and adds

Julian Schwinger

some extra charge to the electron, and it is the combined charge that one measures. The new formulations put observable electron charge and mass into the Hamiltonian function. Schwinger, Tomonaga, and Feynman expected that the theory would still need revision for extreme relativistic energies (where mesons and other particles can be created) so they made calculations in such a way that ex-

Richard P. Feynman

treme energy effects were isolated and separated from moderate energy effects.

The work of Schwinger and Tomonaga was a field theory—their fundamental physical quantities are electric and magnetic fields. On the other hand Feynman's fundamental physical process was the propagation of particles from place to place; his measurable quantities are elements of the scattering or S matrix.

Dr. Schwinger was born in New York City and educated at Columbia University, where he studied under I. I. Rabi. After receiving his PhD in 1939, he spent two years at the University of California at Berkeley, as a National Research Fellow and as a research associate. He then joined the faculty of Purdue University, where he rose to the rank of assistant professor. During the war years he worked at the Radiation Laboratory of the Massachusetts Institute of Technology and as a staff member of the Metallurgical Laboratory of the University of Chicago that was associated with the Manhattan Project. He came to Harvard University in 1945, and was appointed professor of physics there in 1947.

Dr. Feynman is a native of New York City. He took his bachelor's degree at the Massachusetts Institute of Technology in 1939. He was a graduate student of J. A. Wheeler at Princeton University and received his PhD in 1942, where he also worked on the separation of ^{235}U from ^{238}U. From 1942 to 1945 he was group leader in theoretical physics at Los Alamos Scientific Laboratory. After the war he served on the physics faculty at Cornell University and then was appointed professor of theoretical physics at the California Institute of Technology.

Dr. Tomonaga, son of a noted philosopher, Sanjuro Tomonaga, was born in Kyoto and was graduated from Kyoto University in 1929. In 1937 he studied under Heisenberg at the University of Leipzig, and then returned to Kyoto, where he received a PhD in 1939. Two years later he joined the faculty of the Tokyo Bunrika University (now Tokyo University of Education) as professor, and presently holds the position of director of the University's Institute for Optical Research. His previous honors include the Japan Academy Prize, for his work with Masao Kotni on electromagnetism, and the Cultural Medal of Japan.

Arches of Science Prize

Warren Weaver has received the first Arches of Science Award from the Pacific Science Center Foundation in Seattle. The \$25 000 prize and gold medal was given to Dr. Weaver for his "outstanding contributions to the public understanding of the meaning of science to contemporary man."

Associated with the Rockefeller and Sloan Foundations for over 30 years, Dr. Weaver is distinguished both as a science administrator and mathematician specializing in statistics and probability. He is, however, perhaps best known as an interpreter of science for the layman. He served as first chairman of the National Science Foundation's public understanding of science program and was active in organizing the National Association of Science Writers and Columbia University's advanced science writing program. He is also the author of over 100 articles and books in mathematics and physics, as well as popular accounts of science in the public media. Recently, UNESCO's Kalinga Prize was awarded him for his contributions to public understanding of science. A fellow of the American Physical Society and the American Association for the Advancement of Science, Dr. Weaver was AAAS president in 1954.

Guggenheim space prize

M. V. Keldysh of the USSR Academy of Sciences in Moscow has received the 1965 Daniel and Florence Guggenheim International Astronautics Award. Carrying an honorarium of \$1000, the prize was conferred upon Dr. Keldysh by the International Academy of Astronautics during the Sixteenth International Astronautics Congress held in Athens in September. Previous recipients have been Bernard Lovell, James A. Van Allen, Marcel Nicolet, and Wallace O. Fenn.

Dr. Keldysh, a mathematician noted for his studies in mechanics and astronautics, has done research in aerodynamics, fluid dynamics, and vibration theory. In recent years, he has directed work on rocket-propulsion theory and on development of a ballistic theory of space flight and has been an important contributor to the Soviet missile and space program. In other areas he has investigated oscillation theory, theory of waves on the surface of a heavy liquid, impact against water, approximate integration of differential equations, potential theory, conformal-representation mapping, and eigenfunctions and eigenvalues of parameters for non-self-conjugate differential equations.

Born in Riga in 1911, Dr. Keldysh was educated at Moscow University and later joined the Central Aerohydrodynamics Institute. In 1939 he became associated with the Steklov Mathematics Institute and in 1954 was made director of its Department of Applied Mathematics. He was elected a corresponding member of the USSR Academy of Sciences in 1943 and became an academician three years later. Since 1961 he has served as head of the Academy. Dr. Keldysh is also a member of several scientific editorial boards and has been honored with numerous awards, including three Lenin Prizes.

Franklin Institute medals

Frederick Seitz, president of the National Academy of Sciences, was awarded the Franklin Medal, the Franklin Institute's highest honor, during annual medal day ceremonies on October 20th. Dr. Seitz was recognized both for his contributions in solid-state physics and his service as a leader of science.

As a theoretician, Dr. Seitz helped to explain the properties of metallic sodium, luminescence and optically-induced darkening in alkali halide crystals, and crystal defect interactions with practical application of strain hardening of metals. He is also well known for his application of matrix algebra to classification of crystallographic groups and calculation of threshold energy of nuclear radiation required to produce crystal defects in solid materials. His book, *Modern Theory of*