Ernst Stueckelberg (Obituary)

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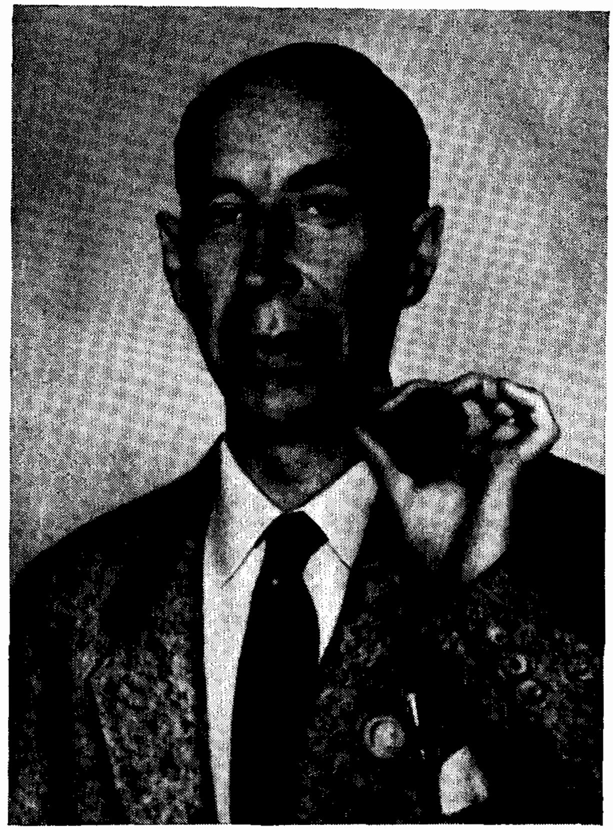
Ernst Karl Gerlach Stueckelberg, one of the most prominent theoretical physicists of this century, professor emeritus of theoretical physics at the universities of Geneva and Lausanne, a scientist of great vision and profound insight who had a significant influence on the evolution of modern quantum field theory, passed away at the age of eighty on September 4, 1984 in Geneva.

Stueckelberg was born on February 1, 1905 in Basel, where he attended school and began his university studies. As was customary at the time he continued his education at a different university: in Munich under Arnold Sommerfeld, returning to Basel to receive his doctorate in 1927. He left Europe that same year for a position of "research associate" at Princeton University on the invitation of K. T. Compton. There, in 1928, he and G. H. Winans successfully explained the continuous spectrum of the H_2 molecule, a problem which eluded other outstanding physicists.[1] This triumph even appeared in the popular press and reached a wide public, which Stueckelberg would later recall with some pride.

In 1930 Stueckelberg was appointed to the rank of assistant professor at Princeton, but he soon returned to Zurich, in Switzerland, to take up a similar position at the University of Zurich in 1933. In 1935 he was appointed associate professor at the University of Geneva; and in 1939, he became a full professor. From 1942 onward he combined this position with a professorship at the university and the Polytechnic in Lausanne.

Stueckelberg's scientific interests covered a broad range of problems from thermodynamics to elementary particle theory, but his most significant results came in quantum field theory.

According to V. Weisskopf's memoirs [see Usp. Fiz. Nauk **138**, 470 (1982); for the English version see Physics Today, **34**, No. 11, 69 (1981)] Stueckelberg was one of the first—if not the first—to recognize and disseminate as early as 1934–1935 the ideas that later laid the foundation for renormalization methods. In particular, he understood the importance of reformulating perturbation theory into a relativistically symmetric form.[2,3,5] Pursuing these ideas he came to the conclusion, already in 1942,[4] that positrons may be taken as electrons of negative energy moving backwards in time. In his well-known 1949 paper Feynman directly cites the appropriate paper of Stueckelberg's. Here Stueckelberg's characteristic approach came to the fore: in every problem he would seize on the few fundamental principles and then uncompromisingly, mercilessly even, extract all the logical consequences.



ERNST STUECKELBERG
(1905–1984)

In 1948–1949 Stueckelberg and his students proposed and began to develop a new method of constructing the scattering matrix,[6–8] based not on solving the Schroedinger equation, but rather on specially formulated general physical postulates of relativistic invariance, unitarity, and causality—where this last condition was taken as constraining particles of positive energy to move forward in time and those of negative energy to move backwards. Subsequent elaboration of Stueckelberg's original approach led to the axiomatic method in scattering matrix theory as an alternative to the well-known method of Tomonaga, Schwinger, and Feynman. In the framework of his original understanding of the scattering matrix, Stueckelberg and his student Rivier in 1948 (a year earlier than Feynman) developed

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from the condition of causality the causal propagation function, which came to be known as the causal propagator q^c.[9]

An important contribution of Stueckelberg's to quantum field theory was his 1951 discovery of boundary divergences,[10] the point being that in renormalizable theories which require introduction of counterterms with derivatives it is impossible to obtain simultaneously a finite renormalized scattering matrix and a finite wavefunction of a system of quantized fields at a fixed moment in time.

Among Stueckelberg's other contributions to the development of field theory were the theory of nuclear forces based on vector boson exchange, the formulation of quantum electrodynamics as the limiting case of a massive photon theory, the theorem stating that in a nonlocal field theory it is impossible to satisfy simultaneously macroscopic causality and unitarity, and much more.

But his greatest success, at least the one that is best known and widely cited even now, was the discovery together with A. Petermann of a special transformation group in renormalized quantum field theory, which he called the "normalization group." The central point of this result, published in 1953,[11] is that the structure of finite randomness in renormalized expressions of quantum electrodynamics allows for finite transformations that have group properties and are equivalent to the renormalization of the electron charge. In the mid-1950s other scientists developed this result into an effective method of improving the accuracy of renormalized perturbation theory in the ultraviolet and infrared regions, known as the renormalization group method. The latter helped in the discovery of asymptotic freedom, i.e., the weakening of strong quark-gluon interactions with decreasing distance, which determined the success of quantum chromodynamics. It also served as the theoretical foundation of Grand Unification theories—the unification of three (electromagnetic and two nuclear—the weak and the strong) of the four fundamental interactions—which led to the theoretical possibility of proton decay and an estimate of its lifetime.

The renormgroup method also proved a powerful tool for the study of nonlinear problems in other branches of physics. In the 1970s its use became widespread in theories of critical phenomena and turbulence, polymer physics, percolation theory, transport theory, and others—gradually becoming a general method of theoretical physics.

In the last two decades of his life Stueckelberg devoted more and more of his attention and effort to thermodynamics. At first it might appear strange that he abandoned quantum field theory, the book to which he added many sterling pages. Perhaps as he got older, however, the questions lying at the very heart of the universe's existence loomed large in his mind. The role of time in the world, which struck him already when he proposed a new interpretation of the positron, that was the problem he hoped to clarify in classical thermodynamics. The results of this undertaking are collected in his only book, "Galilean Phenomenological Thermodynamics",[12] published in 1974.

Prizes and honors came to Stueckelberg relatively late. In 1962 he received honorary degrees from Swiss universities in Bern and Neuchatel, in 1971 he was awarded the Geneva city prize. International acclaim came in 1976, when the German Physical Society awarded him the Max Planck medal. Despite health problems which made it difficult for him to walk, after retiring in 1975 Stueckelberg continued to give his course at the University of Geneva and participate in theoretical seminars at the university and at CERN, retaining an active interest in physics till his last days.

[1]Proc. Nat. Acad. Sci. USA **14**, 867 (1928) (G. H. Winans).
[2]Ann. Phys. (Leipzig) **21**, 367 (1934).
[3]Helv. Phys. Acta **11**, 225 (1938).
[4]Helv. Phys. Acta **14**, 588 (1941).
[5]Nature **153**, 143 (1944).
[6]Helv. Phys. Acta **19**, 241 (1946).
[7]Helv. Phys. Acta **22**, 215 (1949); **23**, suppl. 3, 236 (1950), (D. Rivier).
[8]Helv. Phys. Acta **24**, 153 (1951) (T. A. Green).
[9]Phys. Rev. **74**, 218 (1948) (D. Rivier).
[10]Phys. Rev. **81**, 130 (1951).
[11]Helv. Phys. Acta **26**, 499 (1953) (A. Petermann).
[12]"Thermodynamique phénoménologique galiléenne," Birkäuser-Verlag, Bâle, 1974.

Translated by A. Zaslavsky