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Peter Higgs (1929–2024)

Physicist who lent his name to the Higgs boson

By Chris Quigg
Fermi National Accelerator Laboratory, Batavia, IL, USA.
Email: chris.quigg@gmail.com

Peter Ware Higgs, a particle physics icon, died on 8 April at the age of 94. Higgs illuminated the path to understanding how exact symmetries obeyed by the laws of nature might be masked by an asymmetric ground state that is an outcome of symmetrical laws. In 1964, he posited that a field filling all of space could be the agent that hides the underlying symmetries of the fundamental interactions. When excited, the field reveals itself as a massive unstable particle. In the context of a joint theory of electromagnetism and the weak interaction, that particle—popularly called the Higgs boson—emerged as the keystone of the standard model of particle physics. The decades-long search for the boson engaged the passion of thousands of scientists and engineers and stirred the curiosity of the public the world over.

Peter Higgs was born 29 May 1929 in Newcastle upon Tyne, United Kingdom. He graduated with a BSc and first-class honors in physics from King's College London in 1950. In 1954, he earned his PhD at King's for work on the theory of molecular vibrations under the supervision of Charles Coulson and Christopher Longuet-Higgins. Higgs completed a postdoctoral fellowship at the Tait Institute in Edinburgh. After an interlude in London at Imperial College and University College, he settled in Edinburgh for the rest of his career. He retired in 1996 as professor emeritus at the University of Edinburgh. His research—always solo after his first student paper—moved from chemical physics through quantum gravity and then to symmetries in particle physics.

Symmetry had fascinated Higgs since his student days, so he was primed to appreciate Yoichiro Nambu's and Jeffrey Goldstone's studies of symmetry breaking in particle physics that made analogies to theories of superconductivity. Higgs was particularly attracted to the idea that an underlying symmetry could be hidden by circumstance. Such spontaneously broken symmetries are ubiquitous in the natural world, giving rise, in many settings, to observable massless particles with zero spin.

Field theorists of the mid-1960s confronted a frustrating circumstance. Beautiful theories, called gauge theories, in which symmetries dictate interactions, lead directly to massless spin-1 force particles that, apart from the photon, are not seen in nature. It was widely assumed that spontaneous symmetry breaking would yield additional massless particles, this time with zero spin, but these do not exist. The insight of Higgs and his peers was that gauge theories are different: Spontaneous symmetry breaking leads to massive force particles and predicts one or more massive particles with zero spin. This realization did not reveal a realistic theory of the force that binds protons and neutrons, which had been an implicit motivation for Higgs and others, but it created a theoretical tool of immense power and reach.

In 1967, Steven Weinberg applied the Higgs et al. strategy to a nascent theory linking weak and electromagnetic interactions put forward by Sheldon Glashow in 1960. Weinberg's model predicted massive force carriers for the charge-current and neutral-current weak interactions. It also showed how the "Higgs" field could generate masses for the fundamental constituents, the quarks and leptons. Finally, it implied the existence of a massive unstable scalar boson, which became a focal point for particle physicists.

I met Peter Higgs in 1984 at the Wingspread, Wisconsin, symposium *Fifty Years of Weak Interactions*. The program was rich in personal reminiscences of contributions that had shaped our understanding of the weak interactions—inspiring accounts of the triumphs of native guile and cunning, determined persistence, and flashes of good luck. Peter began by saying that he wanted to disclaim priority for some of the concepts to which his name had been attached. Perhaps, he said, the "Higgs mechanism" would be better labeled the "ABEGHHK'tH mechanism," after all the people (Philip Anderson, Robert Brout, François Englert, Gerald Guralnik, Carl Richard Hagen, Peter Higgs, Tom Kibble, Gerard 't Hooft, and others) who had discovered or rediscovered it.
He did "accept responsibility" for the Higgs boson, given that he had been the first to call attention to its existence in spontaneously broken gauge theories. His generosity of spirit and his clarity of thought and expression left an indelible impression.

The Wingspread symposium agenda concluded with a look at how we hoped to set about completing the elegant but unfinished intellectual edifice the pioneers' work had given us. Simple considerations about the scattering of a pair of weak force particles—the W bosons—showed that a thorough exploration of the energy scale up to a trillion electron volts would reveal the mechanism of electroweak symmetry breaking, whether it be the Higgs boson or something entirely different. That campaign could be carried out in a very-high-energy proton–proton collider producing tens of millions of collisions each second. It was fitting that Peter Higgs and several other pathfinders could be present at the European Laboratory for Particle Physics (CERN) on 4 July 2012 when experimenters announced their discovery of what they called the Brout-Englert-Higgs boson. After that confirmation, Peter and François Englert shared the 2013 Nobel Prize in Physics (Robert Brout was no longer living) "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles." Elaborating the properties of the new particle and the role of the corresponding field in shaping our world remains a preoccupation of particle physics today.

I am among thousands who have devoted their research to extending the path toward understanding electroweak symmetry breaking that Peter opened up. Inspiration was not his only gift to me. Shortly before his death, he sent me a handwritten picture postcard, fan mail for my new book with coauthor Bob Cahn. It was signed "Peter (the boson) Higgs."

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