Kenneth Geddes Wilson

(1936–2013)

Nobel-prizewinning physicist who revolutionized theoretical science.

Before Kenneth Wilson's work, calculations in particle physics were plagued by infinities. Results came from a workaround called renormalization, dubbed "ugly" even by one of its inventors, theoretical physicist Paul Dirac. In the 1970s, Wilson reformulated this method. Almost immediately, renormalization became a respectable and widely used tool, forming the basis of thousands of papers in condensed-matter and particle physics. It is now our primary method for seeing the connections among different theories in the physical sciences.

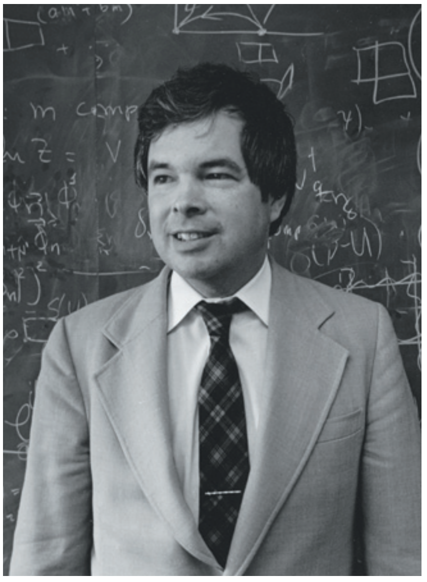
Wilson died on 15 June 2013. Born in 1936 in Waltham, Massachusetts, he started life amid theoretical science. His grandfather taught engineering at the Massachusetts Institute of Technology in Cambridge; his father was a theoretical chemist at Harvard University, also in Cambridge. Like his father, Kenneth Wilson was appointed to the Society of Fellows at Harvard, a group of young scholars picked for their exceptional promise and then given no responsibilities whatsoever.

Ken got his PhD in particle physics under Murray Gell-Mann at the California Institute of Technology in Pasadena. Appointed to the junior faculty at Cornell University in Ithaca, New York, in 1963, Wilson initially proved a disappointment, at least to those who vet promotions by bean counting. Despite having no journal publications before 1969, Wilson's exceptional promise brought him promotion to tenure at Cornell after just two years. Then, in 1971, Wilson revolutionized the mathematical sciences.

Both particle and condensed-matter physics describe observations at length scales set by the experimental apparatus, but depend on processes occurring at much shorter distances. So observation-based theories, whether they are about the elasticity of materials or the collisions of observable 'elementary' particles, cannot accurately describe natural forces acting at small scales.

This weakness showed up in mid-twentieth-century particle physics through the generation of infinities in most calculations. Before Wilson's work, the renormalization method achieved finite results by replacing the infinite quantities in the theory with empirically derived, finite quantities.

During the 1960s, Wilson noted the close analogy between particle physics and phase transitions. (A phase transition is the change of matter from one form to another, such as the boiling of liquid water to produce steam.) Phase transitions had a rich experimental, analytical and numerical tradition, based on well-known science at the atomic or molecular level. As a result, a theory in this area could be verified or disproved by comparison with known results. But a theory was needed to bridge the gap between basic forces at one length scale and observations at a very different scale.



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Ken built a new form of analysis for phase transitions. He focused on theories defined at different length scales, broadening the renormalization calculation of the connection between the scales to include all physical processes, not just the few that might show infinities. He added an analysis in which the eventual result of many changes in length would be a 'fixed point'. This result was easy to analyse because of its scale-independent behaviour.

Soon after Wilson first described his ideas, he worked with Michael Fisher, also at Cornell, to calculate the mathematical form of the interrelation among density, pressure and temperature for a fluid hovering close to its transition from liquid to vapour. The amazingly close agreement of their results with experimental findings helped to accelerate the acceptance of the new renormalization theory.

Wilson also applied his ideas to the quarks that underlie a substantial portion of high-energy theory. He pointed out that these quarks can fall into several thermodynamic phases, differing in behaviour. In the phase that is found all around us, quarks become hard to observe because they are closely bound to one another. This work was important for understanding the basic theory of quantum chromodynamics and its realization in numerical computations, described as lattice gauge theory. This work founded a subfield of science, now practised at many centres.

In 1982, Wilson won a Nobel prize for his work on phase transitions. However, his renormalization has had an impact that is substantially beyond any single area of science. One might argue, as I do, that the connections among 'laws of nature' at different scales of energy, length or aggregation is the root subject of physics. It could then be said that Wilson has provided scientists with the single most relevant tool for understanding the basis of physics.

That was Wilson's's main accomplishment. But it was not all. His work drove us to develop different work styles and new scientific areas. He implicitly encouraged us to emulate computers and computer programs in order to track all the different processes that arise in changing length scales. Wilson was influential in his championing of supercomputers and the National Science Foundation's national scientific supercomputing centres, one of which was established at Cornell in 1985. He constructed computer programs to enable the flexible use of very large computers for research. This work was, in part, carried out with his wife, computer scientist Alison Brown.

Ken was unfailingly generous to those working in his area. For example, he gave very careful credit in his papers to previous workers. I note Ken's kind (and almost unprecedented) inclusion of my name in the title of his first, great, renormalization paper.

The brilliance of Kenneth G. Wilson was dazzling, but he never tried to outshine those about him. He was all quiet competence and deep accomplishments. ■

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