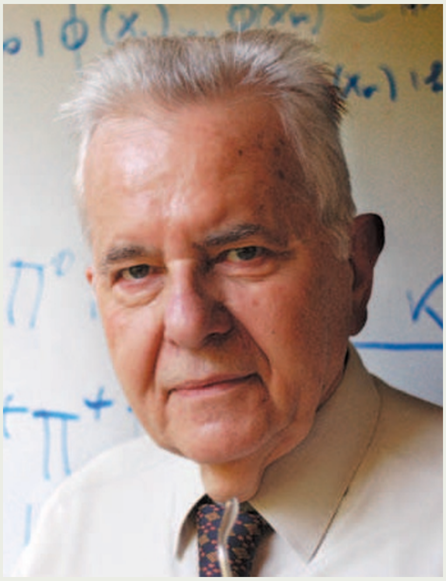
OBITUARY

Nicola Cabibbo (1935–2010)

Pioneer in understanding the weak force of particle physics.



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In his 1961 book *The Theory of Fundamental Processes*, Richard Feynman vividly described the satisfaction that he and Murray Gell-Mann felt at finding an explanation for the close similarity between the Fermi constants describing the β decays of neutrons and muons. Feynman and Gell-Mann had discovered the 'universality' of weak interactions. This is similar to the universality of electromagnetic interactions and thus provided a tantalizing hint of a common origin for the two forces. But the book also recorded Feynman's disquiet that the Fermi constant of 'strange' particles (nuclear particles such as the lambda, comprising an up, a down and a strange quark) turned out to be smaller by a factor of 4 to 5. It was Nicola Cabibbo who reconciled these strange-particle decays with the universality of weak interactions. In doing so, he paved the way to the modern unified theory of the electromagnetic and weak forces that is central to the standard model of particle physics.

Cabibbo died in Rome on 16 August following a severe respiratory illness. The son of a Sicilian lawyer, he was born in the same city on 10 April 1935. He graduated in theoretical physics at the Sapienza University of Rome under the supervision of Bruno Touschek, whom he would always consider his mentor. In the early 1960s, in Frascati just outside Rome, Touschek and his collaborators were building the first collider of electrons and their antiparticles, positrons. With Raoul Gatto, who was also to become a leading figure in particle theory, the young Cabibbo wrote an exploratory paper on the physics that could be studied using electron–positron collisions, a paper that soon became a standard reference in the field.

In 1962, while working at CERN, Europe's particle-physics laboratory near Geneva, Switzerland, Cabibbo found the solution to the puzzle of the weak decays of strange particles. Formulating what came to be known as Cabibbo universality, he assumed that all β decays, whether they involved strange particles or not, had to be described in terms of a weak current that was determined by a single parameter — the Cabibbo angle. Using this angle, now determined to be about 12°, and exploiting the particle symmetries that had been discovered by Gell-Mann and Yuval Ne'eman, Cabibbo could not only explain the β decays of strange particles, but could also account for the small discrepancy between the Fermi constants of neutron and muon β decays.

Cabibbo later reformulated the weak-interaction universality in terms of quarks — the elementary particles that constitute hadronic particles such as protons, neutrons and lambdas. Only three types of quark (up, down and strange) were then known, and Cabibbo showed that β decays could be explained by a coupling between the types of quark encoded in the Cabibbo angle. (Put more technically, the weak interaction couples the up quark to an orthogonal combination of the down and strange quarks, determined by the Cabibbo angle.) This concept of the mixing of the different types of quark had major implications for particle physics, and in 1970, Sheldon Glashow, John Iliopoulos and I extended it to include a fourth type of quark, charm, whose existence was confirmed experimentally in 1974.

Cabibbo universality and the charm quark made it possible to extend the unified electroweak theory, which had been proposed by Steve Weinberg and Abdus Salam, to the interactions of hadrons, ironing out the difficulties that had plagued the three-quark scheme. But the phenomenon of CP violation, observed in the decay of certain elementary particles, also had to be included. To account for it, Makoto Kobayashi and Toshihide Maskawa extended the theory further, introducing two more quarks, the bottom and top. In this six-quark model, Cabibbo's quark-mixing scheme is embedded in what is known as the Cabibbo–Kobayashi–Maskawa matrix.

The success of Cabibbo's theory — now supported by decades of data, including the most recent data from CERN and Fermilab in Batavia, Illinois — and his exceptional talent as a teacher and conference speaker made Cabibbo an internationally known and influential figure. In 1966, he returned from CERN to Italy, where he taught theoretical physics at the universities of L'Aquila and Sapienza, moving in 1981 to the University of Rome Tor Vergata and returning to Sapienza in 1993. In Rome, he created a school of outstanding young particle physicists.

Inspired by Cabibbo's intuition for physics, mathematical skill and personal charisma, the Rome school contributed significantly to establishing what is today known as the standard theory of particle physics — an elaborate framework describing the weak, the strong and the electromagnetic interactions. Among Cabibbo's many achievements are describing electron–positron annihilation into hadrons in terms of point-like entities termed partons; calculation of the contribution of the combined electromagnetic and weak interactions to the anomalous magnetic moment of the muon; and the prediction of a phase transition of nuclear matter to a plasma of quarks and gluons in quantum chromodynamics (QCD) — the particle-physics theory that today describes strong interactions. With Giorgio Parisi, Cabibbo proposed and built a parallel supercomputer, termed the array processor experiment (APE), for calculations in QCD. APE and its subsequent evolutions have proved useful in elucidating basic QCD phenomena in a regime where the usual mathematical approach of perturbation theory cannot be applied.

From 1983 to 1992, Cabibbo served as president of the National Institute of Nuclear Physics in Frascati, making the transition (unexpected to most) to science administration. He was president of the Italian energy agency ENEA from 1993 to 1998, and from 1993 was president of the Pontifical Academy of Sciences, based in the Vatican. He brought to these positions vision, managerial skill and a universally appreciated integrity. In 1991, he became one of the first recipients of the European Physical Society's prize in high-energy and particle physics. He was awarded the American Physical Society's Sakurai prize in 1989 and the Dirac medal in 2010.

Nicola liked teaching, and was still doing so until the last months of his life. Like all great thinkers, he could find simple ways to explain the most difficult concepts. His students were captivated by his simplicity, gentleness and sense of humour. So were all of us who had the privilege to be his collaborators and friends.

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