Nicola Cabibbo

Roma, 10/4/1935 - 16/8/2010

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Disciplina Fisica

Titolo Professore di Fisica teorica presso l'Università 'La Sapienza' e Presidente della PAS dal 1993 al 2010.

Commemoration – Nicola Cabibbo, born in Rome on 10 April 1935, was President of the Pontifical Academy of Sciences for 17 years till his death on 16 August 2010. He was initially appointed as a Pontifical Academician on 9 June 1986 by Pope John Paul II, who also appointed him on 30 March 1993 as President of the Academy. He was, undoubtedly, one of the most important theoretical physicists of our time, and yet he was one of the most humble persons – a perfect gentleman, as well as a highly esteemed President of the Academy. Nicola Cabibbo was one of the fundamental pioneers in the development of high-energy physics. His contributions were in the field of weak interactions; and he did a large part of this work right here in Rome. It was here that the great Enrico Fermi taught physics at the University of Rome, La Sapienza, which became one of the leading Centres of theoretical physics. The work of Italian physicists in the development of high-energy physics has been excellent, and a part of it was awarded the Nobel Prize. There was, of course, the great work of Enrico Fermi on the theory of Beta Decay. One of Fermi's colleagues in Rome was Emilio Segrè, who also won a Nobel Prize for the discovery of the anti-proton. Amongst Fermi's collaborators was the young Ettore Majorana, who was highly gifted in mathematics and whose work on neutrino masses, the famous Majorana Equation and the Majorana Neutrino, is so well known. Several other famous Italian physicists, including Nicola Cabibbo, contributed importantly to this well-established Italian school of physics. The Cabibbo angle appears to be a simple parameter, but it was fundamental to the development of the theory of high-energy physics, particularly of what is called today 'The Standard Model'. We can also recall the experimental work, 60 years ago, which was characterized by what was then referred to as the 'theta-tau' puzzle, raising the question of how the same strange particle could, on one occasion, go into two pions or, otherwise, into three pions. On this basis, Richard Feynman and Murray Gell-Mann proposed in 1958 their famous current x current form of weak interaction theory, which extended Fermi's theory and made it applicable to all forms of weak decays. In a late recognition of Nicola Cabibbo's important contributions to this field of research, the International Council of Theoretical Physics (ICTP) awarded the 2010 Dirac Medal to Nicola Cabibbo and E.C. George Sudarshan on 9 August 2010, just one week before Cabibbo passed away. The underlying theory was a beautiful generalization of the Fermi theory and it also included the axial vector current, in addition to the original vector current of Fermi, in the form of the V-A interaction of Sudarshan and Marshak, thus incorporating the maximal parity violation discovered by T.D. Lee, C.N. Yang and C.S. Wu in 1956. An important feature of the Fermi/Gell-Mann theory was the idea that weak interactions are universal. Cabibbo succeeded in reformulating the hypothesis of universality in such a way that the discrepancy noted in the comparison of the decay rates of the strange particles with those of the non-strange particles could be explained beautifully. This was done in his seminal paper of 1963. By 1963, SU(3) symmetry of Gell-Mann and Ne'eman which was at that time called Unitary Symmetry, was already becoming a part of high energy physics. Following Gell-Mann, Cabibbo took the strangeness-conserving and strangeness-violating weak hadronic currents as members of the same octet representation under SU(3). This allowed him a more precise formulation of the weak interaction. He proposed instead his form of universality that came to be known as Cabibbo Universality. All this was done within the framework of SU(3) and hence the agreement with experimental results helped to establish the usefulness of SU(3) not only in the classification of hadrons, but also in correlating their weak decays. Cabibbo's paper refers to the Gell-Mann-Levy paper, but we must give substantial credit to Cabibbo as the author of Cabibbo Universality; the GellMann-Levy remark remained as a footnote for almost three years and it was Cabibbo who took it seriously and developed it into a full-fledged theory of the leptonic decays of hadrons with predictions that were verified experimentally. Cabibbo himself in his original paper was rather modest; he wrote, 'I will restrict himself to a weaker form of universality'. On this scientific basis other scientists have successfully further developed this field of research. It is Nicola Cabibbo's seminal work that laid the foundation for our modern understanding of the weak interactions among the quarks. Theorists who boldly followed his idea of universality of weak interactions to its logical completion not only successfully predicted the existence of the charmed quark, but also the top and bottom quarks which were necessary for CP violation. Finally, the universality that was formulated by Cabibbo got enshrined in the Standard Model of High-Energy Physics, in the form of the equality of gauge coupling to all the particles. It became a cornerstone of the Standard Model. It can thus be seen that Nicola Cabibbo is one of the several Italian distinguished scientists who laid the building blocks of the particle physics Nicola Cabibbo's interests and concerns were not limited to theoretical physics but they extended to all fields of scientific investigations and to the application of scientific knowledge. This is obvious to all members of the Pontifical Academy of Sciences present in this commemorative session and who very highly appreciate and recognize his guidance as our President for the last 17 years.

M.G.K. Menon and Werner Arber

Most important awards, prizes and academies

Awards: Premio Alcide De Gasperi per le Scienze (1968); J.J. Sakurai Prize for Theoretical Particle Physics of the American Physical Society (1989); High Energy and Particle Physics Prize of the European Physical Society (1991). *Academies*: Socio Nazionale dell'Accademia Nazionale dei Lincei, Rome; Socio Nazionale dell'Accademia delle Scienze, Turin; Foreign Member of the National Academy of Sciences, USA; Foreign Member of the American Academy of Arts and Sciences; Member of the Pontifical Academy of Sciences. Loeb Lecturer, Harvard University (1965).

Summary of scientific research

Nicola Cabibbo was a theoretical physicist who worked on different aspects of elementary particles and their interactions. He made important contributions to the theory of weak interactions, in particular through the discovery of the phenomenon of quark and current mixing. This discovery established the existence of a new class of physical constants, whose first example is the Cabibbo angle which determines the mixing of strange quarks with non-strange quarks. At the same time this discovery clarified the behaviour of weak interactions for different quark species, thus creating the basis for the development of unified theories of weak and electromagnetic interactions. N. Cabibbo carried out (in collaboration with R. Gatto) the first theoretical studies on the use of electron positron colliding beam machines, demonstrating their great promise for revealing new aspects of elementary particle structure. An important contribution to the theory of strong interaction was the demonstration that the extended nature of hadrons as quark composites implies the existence of a new phase of hadronic matter (obtained at high temperature or high density) where quarks are deconfined. An experimental signature for the existence of this phase is given by the exponential nature of the hadron spectrum.

In his final years N. Cabibbo's scientific activity had been centered on the use of large computers for the numerical simulation of quark interactions. He established the methods for applying numerical simulation to the study of weak interaction of quarks. In the same period he became interested in computer architecture and was engaged in building a Supercomputer (APE) particularly adapted to the problems of numerical simulation.

Main publications

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Rencontre de Moriond, Vol. II, (J. Tran Thanh Van, ed.)(1978); Cabibbo, N., ‘Parton Distributions and their Q2 Dependence’, *The Whys of Subnuclear Physics*, Plenum Publishing Corporation (1979); Cabibbo, N. and Maiani, L., ‘The Vanishing of Order-G Mechanical Effects of Cosmic Massive Neutrinos on Bulk Matter’, *Phys. Lett.*, 114B, pp. 115-117 (1982); Cabibbo, N. and Marinari, F., ‘New Method for Updating SU(N) Matrices in Computer Simulations of Gauge Theories’, *Phys. Lett*., 119B, p. 387 (1982); Cabibbo, N., ‘Gauge Theories and Monopoles’ (A Modest Introduction) Techniques and Concepts of High Energy Physics (Thomas Ferbel, ed.), NATO ASI Series, Series B: Physics, vol. 99 (47) Plenum Press (1983), New York, *Proceedings of the Second NATO Advanced Study Institute*, Lake George (July 1982); Allega, M., Cabibbo, N., ‘Acoustic Detection of Superheavy Monopoles in Gravitational Antennas’, *Lett. Nuovo Cimento*, 38, pp. 263-9 (1983); Cabibbo, N., Martinelli, G. and Petronzio, R., ‘Weak Interactions on the Lattice’, *Nuclear Physics*, 244B, pp. 381-91 (1984); Cabibbo, N., ‘Quark Mixing’, *Proceedings of the X Capri Symposium, 30 Years of Elementary Particle Theory* (May 1992).