Weak Interactions (*).

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PART I.

1. – I have been asked by Prof. LEE to introduce this Course with a first lecture on the « History of neutrino Physics ».

One may recognize in this kind request of Prof. LEE the « respect for the rites » so often recommended in the Confucian doctrine; but I doubt of being able to react properly to such a refined kindness giving you a decent account of this history. During thirty years it alines a series of intellectual achievements in Natural Philosophy which have no counterpart in any field of Physics.

Considering only the most fundamental of these achievements we may list:

1) the « neutrino » hypothesis by Pauli in 1931;

2) the Fermi theory in 1934;

3) the discovery of the weak behaviour of the meson by the Cosmic Ray Group in Rome, and the formulation of the Universal Fermi Interaction by KLEIN, LEE, ROSENBLUTH, YANG, PUPPI, TIOMNO and WHEELER between 1946 and 1948;

4) the first neutrino experiment by REINES and COWANS in 1956;

5) the discovery that the neutrino interactions, *i.e.* the weak interactions, violate parity, predicted in 1957 by LEE and YANG followed by the

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(*) The first part of this lecture is based on Pauli's conference: *Old and new history of the neutrino*, in *Aufsätze and Vorträge über Physik and Erkenntnistheorie*. For many extremely fruitful discussions concerning this and the following lectures I wish to express my thanks to Drs. N. CABIBBO, H. FAISSNER, M. VELTMAN, L. RADICATI and A. ZICHICHI.

experiments of WU *et al.* on the β-decay of aligned nuclei, and by similar experiments on μ decay by GARVIN, LEDERMAN and WEINRICH;

6) the two-component neutrino theory by LANDAU, LEE, YANG and SALAM again in 1957;

7) the $V-A$ formulation of the U.F.I. in three independent but equivalent ways by SUDARSHAN and MARSHAK in 1957; by FEYNMAN and GELL-MANN, and by SAKURAI in early 1958;

8) the old idea of the existence of two independent neutrinos, put forward again by NISHIJIMA in 1957 in order to explain the absence of precesses which were otherwise allowed, and resumed by PONTECORVO in 1959 together with the suggestion of using high-energy accelerator in order to extend to high momenta the neutrino physics, shortly followed by a similar suggestion by SCHWARTZ;

9) the experimental evidence that two neutrinos indeed exist given by the Columbia Group, led by LEDERMAN, SCHWARTZ and STEINBERGER in 1962.

In making a short review of this dense history I will not consider all these stages. I will limit myself to recall few aspects which may give an idea of how Physics grows well. This occurs when new experimental facts stimulate theoretical thinking, when theoretical physicists confronted with puzzling facts propose and speculate on new ideas; when the experimental physicists have then to meet the challenge and prove or disprove these new ideas; which—often at first looking as wild guesses—are then found, with great surprise, to be congenial to nature.

2. – The concept of a neutral particle to carry away in an undetectable manner the missing energy and spin observed in β-decay processes was officially introduced by PAULI at the Solvay Conference in 1933. NIELS BOHR was inclined to abandon these fundamental consequences of symmetries in time and space rotation. PAULI boldly defended them and was correct. Twenty-five years later he defended with the same energy the symmetry with respect to space-inversion; however this time he was wrong. It was hard for him, who had already rejected the two-component spinors of WEYL because of parity violation, to give up the idea that the laws of nature were invariant with respect to an operation equivalent to the conversion of a right-handed frame of reference into a left-handed one, but I shall return to this crucial point of the story a bit later. PAULI's defence of the classic space and time symmetries, was based on the ideas that a neutral particle may exist which carrying out in thoroughly undetectable manner the missing energy and angular momentum