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Nobel Prize in Physics 1957

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The Nobel Prize in Physics 1957 was awarded jointly to Chen Ning Yang and Tsung-Dao (T.D.) Lee *"for their penetrating investigation of the so-called parity laws which has led to important discoveries regarding the elementary particles"*

RESEARCH INFORMATION:

The Nobel Prize in Physics to Professor Tsung Dao Lee and Professor Chen Ning Yang for this year is concerned with some of the fundamental physical principles, the so-called parity laws - in the first place the symmetry of Nature with respect to right and left - in their application to elementary particles and their reactions.

When during this century the old dream about atoms came true, it soon became clear not only that reality is by far richer than was the dream but also considerably different from it. The atoms that were found and which one learnt to count and to measure did by no means correspond to the ideal of indivisibility and unchangeability of the old atomists. But instead, there appeared a hitherto unknown, strangely unvisualizable feature of indivisibility in all atomic processes and therefore also behind all usual physical events, without which everything in the world would be in flux. The new edifice of laws, which was the consequence of these discoveries - it is called quantum theory - contains the laws of

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earlier physics as a correct but greatly simplified limiting case. They have a similar relationship to the laws of atomic physics as an airphoto to a near-picture of the same landscape.

The lesson learnt from quantum theory made that the literally unchangeable atoms of the old philosophers were hardly seriously sought in those particles-electrons, protons, and neutrons - from which atoms are made. As the name elementary particles under which they are summarized would seem to indicate, there was nevertheless a certain inclination towards this direction. But already the ordinary elementary particles are by no means unchangeable, which is still more strongly the case with the lot of new, similar particles discovered during later years, the transformations of which now stand at the centre of interest of atomic physicists. In our attempts to find a theory which comprehends all the new facts concerning old and new elementary particles, certain wittingly unreal, symbolic particles appear in our equations, which with a little good will could be regarded as the eternally immutable atoms of philosophers. Of the real elementary particles we could then, following Lao-tse, the old Chinese thinker, say: "The elementary particles, which could be defined, are not the eternal elementary particles". Lao-tse did not talk of elementary particles, of course, but of Tao, the deepest principle of life. And physics is certainly considerably simpler than human life. And there we have powerful auxiliaries in the art of experimentation and mathematics.

As to mathematics and elementary particles it has, in the first place, led to two theories, each of which has been developed by a Nobel Prize winner in Physics, Dirac and Fermi. Hereby the former theory is the outermost wing of the edifice of quantum mechanics, while the latter may be regarded as the first, still unfinished room in the new edifice of elementary particle laws. But they are both concerned with electrons and thus border on one another.

But what has the question of right and left to do with elementary particle physics? Well, in the first place only in a negative way, in that it was assumed almost tacitly, that elementary particle reactions are symmetric with respect to right and left. This assumption

was to play an important part in the elaboration of Fermi's theory. That this assumption was made was very natural, not least in view of the mentioned theory of Dirac, according to which it looked as if the electrons, the best known elementary particles, possessed no feature which would permit a distinction between right and left. In fact, most of us were inclined to regard the symmetry of elementary particles with respect to right and left as a necessary consequence of the general principle of right-left symmetry of Nature. Thanks to Lee and Yang and the experimental discoveries inspired by them we now know that this was a mistake.

The starting-point of Lee and Yang in their revision of the whole question of right-left symmetry in elementary particle reactions were certain strange observations concerning a kind of new particles called K mesons, which looked as if they were in contrast with the assumption mentioned. Even if these observations puzzled greatly many physicists, it was only Lee and Yang who seriously took the consequences of them, in that they asked themselves what kind of experimental support there was for the assumption that all elementary particle processes are symmetric with respect to right and left. The result of their investigation was unexpected, namely that the validity of the symmetry assumption even in the best known processes had no experimental support whatsoever, the reason being that all experiments had been so arranged as to give the same result whether the assumption was valid or not. As if one had thought that Olav Tryggveson had his heart in the middle of the body because he was equally skilled with the left as with the right hand. Lee and Yang did not confine themselves to this negative statement but devised a number of experiments which would make it possible to test the right-left symmetry in different elementary particle transformations, and proposed them to their experimental colleagues. The first of these experiments was carried out by the Chinese physicist, Mrs. C.S. Wu and her collaborators. Very schematically it consisted in the following. Atomic nuclei of a radioactive isotope of the metal cobalt were exposed at very low temperature to a magnetic field - they are themselves small magnets - whereby they became directed just

like compass needles. The distribution as to direction of the electrons due to radioactivity was then investigated.

Let us assume that the magnetic field is created by means of a coil placed like a spool of thread on a table, and that the electric current is flowing counterclockwise in the wire. Then the north poles of the cobalt nuclei will be directed upwards. The experiment, now, gave the result that the electrons from the radioactive process with this arrangement were preferentially thrown downwards towards the floor. From this it follows unambiguously that the process lacks that right-left symmetry, which one had earlier assumed. Thus, by means of this experiment it could be explained to a person, who did not know it - let us say an inhabitant of a distant stellar system - what we mean by right and left. In fact, it would be sufficient to ask him to arrange the experiment so as to make the preferential direction of the electrons point downwards. The current will then have the same direction as that in which he has to turn at the command "left face".

However - and this is a thing of the utmost importance for the incorporation of the new discoveries into our edifice of physical laws - the person on the distant planet will be able to follow our prescriptions only if he knows what we mean by the direction of an electric current. And to know this he must know that our atoms and his are made up of the same elementary particles. We know, however, that not only are there double sets of electrons - positive and negative - but that the same holds for protons and neutrons, the building stones of atomic nuclei. It is therefore possible that his atoms contrary to ours would consist of positive electrons and negative nuclei. If they did, he would judge the direction of the current opposite to what we would do, with the result that he would call right left and left right. In stating this we have tacitly made an assumption which is not quite confirmed as yet but which, as far as the experiments go, seems probable, namely that the results of all experiments performed with the opposite kind of elementary particles would be just such as to reestablish the right-left symmetry. With other words, one should be able to regard the antiparticles not only as the electric opposites of the particles but also as their mirror images

Professor Lee and Professor Yang. In the very incomplete sketch of your new work I have just made in Swedish, time has not allowed me to mention the many other beautiful contributions to theoretical physics made by each one of you, nor could I at all do justice to the enthusiasm your new achievement has aroused among physicists. Through your consistent and unprejudiced thinking you have been able to break a most puzzling deadlock in the field of elementary particle physics where now experimental and theoretical work is pouring forth as the result of your brilliant achievement.

It is with great satisfaction, therefore, that The Royal Swedish Academy of Sciences has decided to award you this year's Nobel Prize for Physics for your fundamental contributions to this branch of science.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1957/press.html