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Nobel Prize in Physics 1979

Sheldon Lee Glashow

Abdus Salam

Steven Weinberg

The Nobel Prize in Physics 1979 was awarded jointly to Sheldon Lee Glashow, Abdus Salam and Steven Weinberg *"for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including, inter alia, the prediction of the weak neutral current"*.

Information about winners:

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Abdus Salam,
International Centre for Theoretical Physics, Italy and Imperial College, Great Britain,
Steven Weinberg,
Harvard University, USA,

RESEARCH INFORMATION:

Physics, like other sciences, aspires to find common causes for apparently unrelated natural or experimental observations. A classical example is the force of gravitation introduced by Newton to explain such disparate phenomena as the apple falling to the ground and the moon moving around the earth.

Another example occurred in the 19th century when it was realized, mainly through the work of Oersted in Denmark and Faraday in England, that electricity and magnetism are closely related, and are really different aspects of the electromagnetic force or interaction between charges. The final synthesis was presented in the

1860's by Maxwell in England. His work predicted the existence of electromagnetic waves and interpreted light as an electromagnetic wave phenomenon.

The discovery of the radioactivity of certain heavy elements towards the end of last century, and the ensuing development of the physics of the atomic nucleus, led to the introduction of two new forces or interactions: the strong and the weak nuclear forces. Unlike gravitation and electromagnetism these forces act only at very short distances, of the order of nuclear diameters or less. While the strong interaction keeps protons and neutrons together in the nucleus, the weak interaction causes the so-called radioactive beta-decay. The typical process is the decay of the neutron: the neutron, with charge zero, is transformed into a positively charged proton, with the emission of a negatively charged electron and a neutral, massless particle, the neutrino.

Although the weak interaction is much weaker than both the strong and the electromagnetic interactions, it is of great importance in many connections. The actual strength of the weak interaction is also of significance. The energy of the sun, all-important for life on earth, is produced when hydrogen fuses or burns into helium in a chain of nuclear reactions occurring in the interior of the sun. The first reaction in this chain, the transformation of hydrogen into heavy hydrogen (deuterium), is caused by the weak force. Without this force solar energy production would not be possible. Again, had the weak force been much stronger, the life span of the sun would have been too short for life to have had time to evolve on any planet. The weak interaction finds practical application in the radioactive elements used in medicine and technology, which are in general beta-radioactive, and in the beta-decay of a carbon isotope into nitrogen, which is the basis for the carbon-14 method for dating of organic archaeological remains.

Theories of weak interaction

A first theory or weak interaction was put forward already in 1934 by the Italian physicist Fermi. However, a satisfactory description of the weak interaction between particles at low energy could be given only after the discovery in 1956 that the weak force differs from the other forces in not being reflection symmetric; in other words, the weak force makes a distinction between left and right. Although this theory was valid only for low energies and thus had a restricted domain of validity, it suggested a certain kinship between the week and the electromagnetic interactions.

In a series of separate works in the 1960's this year's Nobel Prize winners, Glashow, Salam and Weinberg developed a theory which is applicable also at higher energies, and which at the same time unifies the weak and electromagnetic interactions in a common formalism. Glashow, Salam and Weinberg started from earlier contributions by other scientists. Of special importance was a generalization of the so-called gauge principle for the description of the electromagnetic interaction. This generalization was worked out around the middle of the 1950's by Yang and Mills in USA. After the fundamental work in the 1960's the theory has been further developed. An important contribution was made in 1971 by the young Dutch physicist van't Hooft.

The theory predicts among other things the existence of a new type of weak interaction, in which the reacting particles do not change their charges. This behaviour is similar to what happens in the electromagnetic interaction, and one says that the interaction proceeds via a neutral current. One should contrast this with the beta-decay of the neutron, where the charge is altered when the neutron is changed into a proton.

First observation of the weak neutral current

The first observation of an effect of the new type of weak interaction was made in 1973 at the European nuclear research laboratory, CERN, in Geneva in an experiment where nuclei were bombarded with a beam of neutrinos. Since then a series of neutrino experiments at CERN and at the Fermi Laboratory near Chicago have given results in good agreement with theory. Other laboratories have also made successful tests of effects of the weak neutral current interaction. Of special interest is a result, published in the summer of 1978, of an experiment at the electron accelerator at SLAC in Stanford, USA. In this experiment the scattering of high energy electrons on deuterium nuclei was studied and an effect due to a direct interplay between the electronmagnetic and weak parts of the unified interaction could be observed.

Interaction carried by particles

An important consequence of the theory is that the weak interaction is carried by particles having some properties in common - with the photon, which carries the electromagnetic interaction between charged particles. These so-called weak vector bosons differ from the massless photon primarily by having a large mass; this corresponds to the short range of the weak interaction. The theory predicts masses of the order of one hundred proton masses, but today's particle accelerators are not powerful enough to be able to produce these particles.

The contributions awarded this year's Nobel Prize in physics have been of great importance for the intense development of particle physics in this decade.

<u>For more details please visit:</u>

http://www.nobelprize.org/nobel_prizes/physics/laureates/1979/press.html