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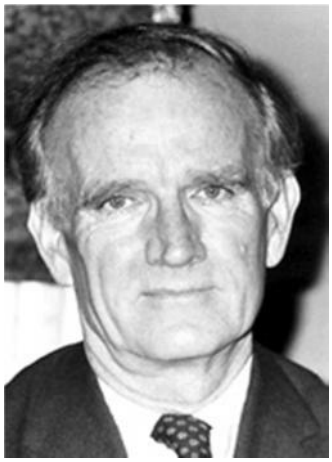
Nobel Prize in Physics 1980

James Watson Cronin



Val Logsdon Fitch

The Nobel Prize in Physics 1980 was awarded jointly to James Watson Cronin and Val Logsdon Fitch *"for the discovery of violations of fundamental symmetry principles in the decay of neutral K-mesons"*

Information about winners:

The Royal Swedish Academy of Sciences has decided to award the 1980 Nobel Prize in Physics to Professor **James W. Cronin**, University of Chicago, USA and Professor **Val L. Fitch**, Princeton University, USA, **for the discovery of violations of fundamental symmetry principles in the decay of neutral K-mesons**.

RESEARCH INFORMATION:

The discovery was made at Brookhaven National Laboratory by a research group led by James Cronin and Val Fitch who also initiated the search. Using the proton accelerator AGS a beam of neutral elementary particles was produced. Their radioactive decay in flight was recorded and measured with great precision. The specially designed detector arrangement was large and complicated. All the difficulties encountered in the analyses of the data were overcome in a skilful and convincing way. The type of neutral K-

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mesons which Cronin and Fitch chose to study are remarkable since they can be regarded to consist of one half ordinary matter and the other half antimatter.

Three symmetry principles

One of the three symmetry principles says that the laws of Nature are exactly alike for both antimatter and ordinary matter. The neutral K-mesons are the most suitable test bodies for a critical and sensitive test of the validity of this principle, which was shown by Cronin and Fitch. The other two symmetry principles state that the fundamental laws have exact mirror symmetry and time reflection symmetry - by the latter is understood symmetry under motion reversal.

The situation before the prize-winning discovery

Complete symmetry is valid for the laws which describe electric and magnetic phenomena, which encompass most things in our daily lives. This is true of all three symmetries. They are also respected by gravitation and by strong interactions (= a force between elementary-particles). On the other hand there is a maximal lack of left-right symmetry, i.e. mirror symmetry in one type of physical processes - the radioactive decays. It was understood by T.D. Lee and C.N. Yang, Nobel Prize-winners in 1957, that the violation of the symmetry was deeply rooted in the very law of weak interactions, which cause the radioactive decays and related processes. The almost self-evident statement which ceased to be valid in 1957, says that the mirror image of a physical process is always a possible physical process.

However, already in 1957 the conclusion could be avoided that Nature makes an absolute distinction between left and right. Nor did the radioactive processes show complete symmetry' between matter and antimatter. One lack of symmetry was cancelled by the other in a complete and elegant way. Thus, the mirror image of a physical process in our world is always a possible process in the antiworld and vice versa. If the universe consists also of antimatter, possible inhabitants on another planet could not then by themselves determine if they consist of the one or the other type of atoms.

Symmetry by time reversal

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The conclusion in 1957 that the two symmetry violations cancelled each other was highly satisfactory since it allowed the third symmetry principle to keep its validity. This principle says that the fundamental laws do not change when all motions are reversed. Such symmetry by time reversal is in fact valid for all processes governed by electromagnetic forces. It is therefore, a cornerstone in physics and chemistry. The symmetry is also valid for processes controlled by gravitational and strong forces. Due to the mutual cancellation of the symmetry violations in weak processes we could consider time reversal symmetry to continue to be generally valid. This became a new cornerstone.

Consequences of the prize-winning discovery

The result of the prize-winning work showed for the first, time that the left-right asymmetry is not always completely compensated by transforming from matter to antimatter. This result has been verified in several similar experiments in other laboratories and by other research groups. This led to a situation in which the new cornerstone was overthrown. All attempts have been unsuccessful to avoid such a radically new conclusion as that which says that perfect symmetry by time reversal is not always true. The new knowledge permits us to make a distinction between matter and antimatter in an absolute and not only relative way. The left and right directions could then also be given absolute meaning, thus loosing the arbitrariness of definition.

The search for the deeper causes of the symmetry violations discovered in the experiment by Cronin and Fitch is actively pursued at present. The progress in elementary particle physics during recent years has created new interesting possibilities.

The new truth reached by the discovery has recently also been incorporated as an important ingredient in cosmological speculations The aim has been to try to understand how a universe, originally very hot and symmetric, could avoid that matter and antimatter almost immediately annihilated each other. In other words, efforts have been made to describe how the matter we are made of was once created in a Big Bang and how it could survive the birth pains.

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The discovery emphasizes, once again, that even almost self evident principles in science cannot be regarded fully valid until they have been critically examined in precise experiments.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1980/press.html