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Nobel Prize in Physics 1951

Sir John Douglas Cockcroft

Ernest Thomas Sinton Walton

The Nobel Prize in Physics 1951 was awarded jointly to Sir John Douglas Cockcroft and Ernest Thomas Sinton Walton *"for their pioneer work on the transmutation of atomic nuclei by artificially accelerated atomic particles"*

RESEARCH INFORMATION:

By giving the Nobel Prize in Physics of this year to Sir John Cockcroft, Director of the Atomic Energy Research Establishment at Harwell, and Professor Ernest Walton of Dublin University, the Swedish Academy of Sciences has rewarded a discovery which stands out as a milestone in nuclear research.

At the beginning of this century, the study of the naturally radioactive substances had shown that their property of emitting radiation is connected with spontaneous transmutations of their atoms. It appeared, however, to be beyond human power to influence the course of these processes.

The radiation emitted by a radium source contains swiftly moving and positively charged helium atoms. By investigating the way in which these particles are deflected by other atoms, the great nuclear scientist Rutherford found in 1911 that an atom has a positive nucleus which is very small compared to the whole atom but contains most of its mass. Besides the nucleus, the atom contains negative electrons, moving around the nucleus.

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Continuing these investigations, Rutherford was able in 1919 to produce transmutations of atomic nuclei by bombarding nitrogen with helium nuclei from a radium source. Some of the helium nuclei had enough energy to overcome the repelling electric field and to penetrate into the nitrogen nucleus, in those rare cases when they struck such a nucleus. The nitrogen nucleus thereupon turned into an oxygen nucleus, while a hydrogen nucleus was emitted.

Thus it became possible by external means to transform nitrogen into oxygen, i.e., to transmute one element into another.

However, only a very few nuclear transmutations could be produced by these natural projectiles, the helium nuclei from radioactive substances. In order to produce nuclear transmutations on a larger scale, and thus obtain further insight into the structure of atomic nuclei, a more powerful stream of projectiles was needed.

Accordingly, the end of the 1920's saw investigations of the possibility of accelerating charged particles to high energies, with the ultimate aim of using these particles to produce nuclear transmutations. This year's Nobel Laureates in Physics were the first to succeed in this task, by their joint work at the Cavendish Laboratory in Cambridge, of which Rutherford was at that time the director. In planning this work, they realized the importance of certain contemporary theoretical studies by Gurney and Condon, and by Gamow. This work had shown that, because of the wave properties of matter, there is a certain probability for a positively charged particle to penetrate into a nucleus even if, according to ordinary mechanical concepts, the velocity of the particle does not suffice to overcome the electric repulsion from the nucleus. Cockcroft had emphasized that the conditions are particularly favourable if hydrogen nuclei are used as projectiles, and that an accelerating voltage of only a few hundred thousand volts should suffice to give observable transmutations of light elements.

The work of Cockcroft and Walton was a bold thrust forward into a new domain of research. Great difficulties had to be overcome before they were able to achieve their first successful experiments at the beginning of 1932. By then, they had constructed an apparatus which, by multiplication and rectification of the voltage from a transformer, could produce a nearly constant voltage of about six hundred thousand volts. They had also constructed a discharge tube in which hydrogen nuclei were accelerated. Causing these particles to strike a lithium layer, Cockcroft and Walton observed that helium nuclei were emitted from the lithium. Their interpretation of this phenomenon was that a lithium nucleus into which a hydrogen nucleus has penetrated breaks up into two helium nuclei, which are emitted with high energy, in nearly opposite directions. This interpretation was later fully confirmed.

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Thus, for the first time, a nuclear transmutation was produced by means entirely under human control.

In order to get a detectable transmutation of lithium, a voltage of little more than one hundred thousand volts was required. The number of transmutations rose quickly as the voltage was increased. The corroboration obtained in this way for the theory which Gamow and others had propounded, and which was referred to above, was of great importance.

The analysis made by Cockcroft and Walton of the energy relations in a transmutation is of particular interest, because a verification was provided by this analysis for Einstein's law concerning the equivalence of mass and energy. Energy is liberated in the transmutation of lithium, because the total kinetic energy of the helium nuclei produced is greater than that of the original nuclei. According to Einstein's law, this gain in energy must be paid for by a corresponding loss in the mass of the atomic nuclei. This assertion was satisfactorily confirmed by Cockcroft and Walton, experimental errors being taken into consideration. Somewhat later, more exact investigations based on the same principles gave a complete verification of Einstein's law. Thus a powerful method was obtained for comparing masses of atomic nuclei.

In subsequent work, Cockcroft and Walton investigated the transmutations of many other atomic nuclei. Their techniques and results remain a model for nuclear research. As projectiles, they also used the nuclei of heavy hydrogen, which had then just been discovered. As end products, several atomic nuclei were obtained which had not been known previously. Following the discovery of artificially radioactive elements, by Frédéric and Irène Joliot-Curie, they found that such elements can also be produced by irradiation with hydrogen nuclei.

The investigations of Cockcroft and Walton disclosed a new and fertile domain of research, consisting of the study of nuclear transmutations of various types.

Their discoveries initiated a period of rapid development in nuclear physics. Besides the apparatus of Cockcroft and Walton, the cyclotron constructed by Lawrence, and various other particle accelerators played important roles. By its stimulation of new theoretical and experimental advances, the work of Cockcroft and Walton displayed its fundamental importance. Indeed, this work may be said to have introduced a totally new epoch in nuclear research

Sir John Cockcroft, Professor Ernest Walton. The great nuclear scientist Rutherford, with whose work your discovery is closely connected, sometimes used to say: "it is the first step that counts". This saying may be applied in the truest sense to your discovery of the

transmutations of atomic nuclei by artificially accelerated particles. Indeed, this work of yours opened up a new and fruitful field of research which was eagerly seized upon by scientific workers the world over. It has profoundly influenced the whole subsequent course of nuclear physics. It has been of decisive importance for the achievement of new insight into the properties of atomic nuclei, which could not even have been dreamt of before. Your work thus stands out as a landmark in the history of science.

On behalf of the Royal Swedish Academy of Sciences may I extend to you our warmest congratulations. I now ask you to receive your Nobel Prize from the hands of His Majesty the King.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1951/press.html