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Nobel Prize in Physics 1963

Eugene Paul Wigner

Maria Goeppert Mayer

J. Hans D. Jensen

The Nobel Prize in Physics 1963 was divided, one half awarded to Eugene Paul Wigner *"for his contributions to the theory of the atomic nucleus and the elementary particles, particularly through the discovery and application of fundamental symmetry principles"*, the other half jointly to Maria Goeppert Mayer and J. Hans D. Jensen *"for their discoveries concerning nuclear shell structure"*.

RESEARCH INFORMATION:

The discoveries by Eugene Wigner, Maria Goeppert Mayer and Hans Jensen for which this year's Nobel Prize in physics has been awarded, concern the theory of the atomic nuclei and the elementary particles. They are based on the highly successful atomic research of the first three decades of this century which showed that an atom consists of a small nucleus and a surrounding cloud of electrons which revolve around the nucleus and thereby follow laws which had been formulated in the so-called quantum mechanics. To the exploration of the atomic nuclei was given a firm foundation in the early 1930's when it was found that the nuclei are built up by protons and neutrons and that the motion of these so-called nucleons is governed by the laws of quantum mechanics.

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In order to be able to calculate the motion of the nucleons it was, however, necessary to know also the forces which act between them. A very important step in the investigation of these forces was taken by Wigner in 1933 when he found, deducing from some experiments, that the force between two nucleons is very weak except when their distance apart is very small but that the force is then a million times stronger than the electric forces between the electrons in the outer part of the atoms. Wigner discovered later other important properties of the nuclear forces.

Nothwithstanding the efforts of many physicists our knowledge of the nuclear forces is yet rather incomplete. It was therefore fundamentally important that Wigner could show that most essential properties of the nuclei follow from generally valid symmetries of the laws of motion. Earlier Wigner had performed pioneering work by studying such symmetries in the laws of motion for the electrons and had made important discoveries by investigating e.g. those symmetries which express the fact that the laws mentioned make no difference between left and right and that backward in time according to them is equivalent to forward in time. These investigations were extended by Wigner to the atomic nuclei at the end of the 1930's and he explored then also the newly discovered symmetry property of the force between two nucleons to be the same whether either of the nucleons is a proton or a neutron. This work by Wigner and his other investigations of the symmetry principles in physics are important far beyond nuclear physics proper. His methods and results have become an indispensable guide for the interpretation of the rich and complicated picture which has emerged from recent years' experimental research on elementary particles. They were also an important preliminary for the deeper penetration into and the partial revision of the earlier concepts concerning the right-left symmetry which was accomplished by Yang and Lee. They were therefore awarded the Nobel Prize in Physics of 1957.

Wigner has made many other important contributions to nuclear physics. He has given a general theory of nuclear reactions and has made decisive contributions to the

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practical use of nuclear energy. He has, often in collaboration with younger scientists, broken new paths in many other domains of physics.

An initially independent line of research in nuclear physics has been the attempts to find models for the atomic nuclei which visualize the motion of the nucleons.

It was found during the 1920's and in particular during the 1930's that the protons and the neutrons each form particularly stable systems in an atomic nucleus when the numbers of either kind of nucleons is one of the so-called magic numbers 2, 8, 20, 28, 50, 82 and 126. Several physicists, in particular Elsasser, tried to interpret the magic numbers in analogy to Niels Bohr's successful explanation of the periodic system of the elements. It was then assumed that the nucleons move in orbits in a common field of force and that these orbits are arranged in so-called shells which are energetically well separated. The magic numbers should correspond to complete shells. This interpretation was successful for light nuclei. It was, however, not possible to explain more than the three first magic numbers and for many years another model dominated.

A paper published by Goeppert Mayer in 1948 marked the beginning of a new era in the appreciation of the shell model. For the first time convincing evidence was there given for the existence of the higher magic numbers and it was stressed that the experiments support the existence of closed shells very strongly.

Somewhat later Goeppert Mayer and independently Haxel, Jensen and Suess published the new idea, which was needed for the explanation of the higher magic numbers. The idea was that a nucleon should have different energies when it "spins" in the same or opposite sense as it revolves around the nucleus.

Goeppert Mayer and Jensen collaborated later on the development of the shell model. They published together a book, where they applied the model to the extensive experimental material on atomic nuclei. They gave convincing evidence for the great importance of the shell model in systematizing this material and predicting new phenomena concerning the ground state and the low excited states of the nuclei. The general methods introduced by Wigner have been most important for the applications of

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the shell model. It has also been possible to give a deeper justification of the shell model. Its fundamental importance has thereby been further confirmed.

Professor Wigner. In the late 1920's you laid the foundation of the theory of symmetries in quantum mechanics and introduced new ideas and methods which you have later further developed and successfully applied to some of the most fundamental problems in physics. This work and your other contributions have been of farreaching importance, indeed essential, for the development of the nuclear and elementary particle physics of our time.

Professor Goeppert Mayer, Professor Jensen. Your work on the shell model which you started independently and then pursued in collaboration has shed new light on the structure of atomic nuclei. It constitutes a most striking advance in the correlation of nuclear properties. Your work has inspired an ever increasing number of new investigations and has been indispensable for the later work, both experimental and theoretical, on atomic nuclei.

Professor Wigner, Professor Goeppert Mayer, Professor Jensen. On behalf of the Academy I wish to extend to you our hearty congratulations and now ask you to receive from the Hands of His Majesty the King the Nobel Prize for Physics for the year 1963.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1963/press.html