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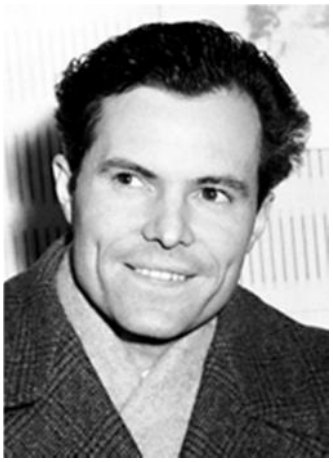
Nobel Prize in Physics 1961

Robert Hofstadter



Rudolf Ludwig Mössbauer

The Nobel Prize in Physics 1961 was divided equally between Robert Hofstadter *"for his pioneering studies of electron scattering in atomic nuclei and for his thereby achieved discoveries concerning the structure of the nucleons"* and Rudolf Ludwig Mössbauer *"for his researches concerning the resonance absorption of gamma radiation and his discovery in this connection of the effect which bears his name"*.

RESEARCH INFORMATION:

Since Rutherford's discovery of the atomic nucleus fifty years ago, one of the most fundamental problems in physics has been to investigate how it is constituted. The ideas on this question could be firmly founded when, shortly after 1930, a neutral particle called the neutron was discovered which has almost the same mass as the hydrogen nucleus i.e. the proton. A theory for the atomic nuclei was proposed according to which they are composed of protons and neutrons which are together called the nucleons. A few years later, Yukawa gave a theory of the forces which keep the nucleons together. It could according to this theory be expected that the nucleons have themselves a complicated inner structure.

Professor Robert Hofstadter has developed a new experimental method for the investigation of the inner structure of the composite atomic nuclei and also of the single

nucleons. His method is to bombard the atomic nuclei with electrons of very high energy. The electrons can penetrate the atomic nuclei and are then deviated by the strong electric and magnetic forces inside the nuclei. By separating the scattered electrons of different energies in magnetic spectrometers and by measuring afterwards the number of electrons which have been deviated to each particular direction, Hofstadter has succeeded in obtaining detailed knowledge of the distribution of the electric charge in the nuclei. For the nucleons, important results have also been found concerning the distribution of their magnetic moments.

The experimental method used by Hofstadter is connected with the principles of the ordinary electron microscope. Here the possibilities to observe details are increased by raising the voltage which accelerates the electrons. As the dimensions of the atomic nuclei are of the order of a ten-billionth of a centimeter, Hofstadter had in order to find their structure to bombard them with electrons of a very high energy. The highest energy used was equivalent to an accelerating voltage of nearly one billion volts. When Hofstadter in 1950 began his work at Stanford University a linear accelerator had already been constructed there and was later supplemented to give the electrons this energy. Hofstadter has built a complicated experimental installation in order to make possible the measurements of the scattering with the accuracy required. He has in a very skilful manner managed to achieve great precision in spite of the very large dimensions of the apparatus.

Hofstadter's results have opened fundamentally new aspects on the properties of the nucleons. His investigations form a pioneering work which in the last years has been beautifully confirmed by similar experiments at Cornell University. It must be expected that investigations of this kind will be made at other institutes also. Electron accelerators which are expected to come into operation in some years will probably increase further our knowledge in this field.

Professor Rudolf Mössbauer's investigations concern the emission and absorption of gamma radiation by the atomic nuclei. This radiation is of the same kind as the light and the radio waves. It is well known that incoming radio waves can be received only if the

receiver is tuned to the same frequency as the sender. Resonance is then taking place. It has since long been tried to observe the corresponding phenomenon for nuclei, where it is called "resonance absorption". The method was to let gamma radiation from some kind of nuclei act upon other nuclei of exactly the same kind. There is however a certain difficulty connected with this experiment. The gamma radiation can be considered as made up of particles. When emitting a gamma particle the atom receives a recoil whereby the energy and therefore also the frequency of the gamma radiation is decreased. The same phenomenon occurs when the gamma particle is absorbed in the receiving nucleus. The resonance will be completely destroyed if the frequency change is not compensated for, as had been done already before Mössbauer's work. Mössbauer discovered experimentally and showed also theoretically that for atoms bound in a solid, an appreciable part of the radiation can be emitted without frequency change whereby the resonance absorption can be studied directly. This discovery was published by Mössbauer in 1958. Because of the very small width of the gamma lines the resonance is very sharp and can, as Mössbauer found, be influenced and finally inhibited by the Doppler effect if the source or the absorber for the gamma radiation is moved. The velocities required depend upon the sharpness of the gamma line and can be as small as some millimeters per hour.

Mössbauer's discovery has been received with considerable interest. Research on the Mössbauer effect has been started at a great number of places. It has thereby been possible to verify in the laboratory, fundamental consequences of Einstein's theory of relativity. Other important applications depend on the separation and displacement of nuclear energy levels which occur in solids because of the influence of the surroundings. Many phenomena of this kind can in spite of their smallness be studied by the Mössbauer effect. It has been possible in this way to get most important information on the properties of solids.

Mössbauer made his discovery when he investigated the resonance absorption on the suggestion of Professor Maier-Leibnitz in München. He found then some unexpected results which he investigated systematically and was thereby led to his discovery.

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Professor Hofstadter. You have in your pioneering investigations on the atomic nuclei and the single nucleons, revealed features of their structures which are fundamentally important for the understanding of these almost inconceivably small systems. Your work is characterized by a precision which has scarcely been attained before in high-energy physics. You have achieved this precision by improving unrelentingly your methods and equipment in the course of time. Your results have quite recently stimulated the discovery of new particles which seem to be essential for the understanding of the forces acting in the atomic nuclei.

Professor Mössbauer. While doing research for your doctor's thesis you have discovered an unexpected effect which now bears your name. You have explained this effect experimentally and theoretically, and thereby created a device which is of fundamental importance in numerous realms of physics, and which is nowadays being investigated and put to use in a large number of physical laboratories. By your discovery it has become possible to examine precisely, numerous important phenomena formerly beyond or at the limit of attainable accuracy of measurement.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1961/press.html