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Nobel Prize in Physics 1950

Cecil Frank Powell

The Nobel Prize in Physics 1950 was awarded to Cecil Powell *"for his development of the photographic method of studying nuclear processes and his discoveries regarding mesons made with this method"*.

RESEARCH INFORMATION:

In awarding this year's Nobel Prize in Physics to Professor C.F. Powell of Bristol, the Swedish Academy of Sciences cited his development of the photographic method for the study of nuclear processes and his discoveries concerning the mesons.

The photographic method used by Professor Powell is based on the fact that after an electrically charged particle has passed through a photographic emulsion, the silver bromide grains of the emulsion can be developed, making the path of the particle appear as a dark line which is, actually, a series of blackened grains with longer or shorter intervals between. The distance between the grains is proportional to the speed of the particle; the greater the speed of the particle, the greater the distance, which circumstance is connected with the fact that a swift particle has less power of ionizing than a slow one.

The method is not new; it came into use in the early years of the 20th century as a means of demonstrating radioactive radiation. For the use of the method in the study of nuclear processes it was first necessary to have emulsions sensitive to various kinds of charged particles, and especially to very swift particles. The problem was brought nearer its solution in the early thirties when it was found that sensitizing the plates made them react to swift protons. The method was difficult, however, and it was not widely used.

Emulsions which reacted to swift protons without previous sensitizing were produced independently in 1935 by Zhdanov in Leningrad and by the Ilford Laboratories.

In nuclear physics the photographic method had not been generally accepted even by the end of the thirties, despite the fact that various researchers had used it for studying cosmic radiation. Nuclear physicists were sceptical of the method because divergent results had been obtained in calculating the energy of the particles from measurements of the length of their traces. They placed more confidence in the so-called "Wilson chamber", where the radiation falls into an expansion chamber filled with moisture-saturated air or another gas. The gas is cooled by suddenly expanding the chamber, and drops of mist are deposited on the ions formed in the path of the particles. Under proper lighting, the paths of the particles which are in the chamber at the moment of expansion appear as cloud tracks.

It is Professor Powell's merit to have dispersed this scepticism regarding the photographic method and to have made it an extremely effective aid in investigating certain nuclear processes as well as cosmic radiation and the resultant nuclear phenomena. Using the new Ilford half-tone plates, he began to investigate the usefulness and reliability of the photographic method for the study of nuclear processes, and in a series of projects from 1939 to 1945 he and his collaborators went into various nuclear processes while introducing successive improvements in the treatment of the material, the research technique, and the optical equipment for analyzing the particle traces. These studies have given convincing proof that in this kind of research the photographic method is quite the equal of the Wilson chamber and counter, and even, in some instances, its superior. The savings of time and material effected with the photographic method have been proved by comparisons between similar investigations made with both the Wilson chamber and the photographic method. In one such experiment with the Wilson chamber 20,000 stereoscopic photos produced 1,600 particle traces suitable for measurement. Professor Powell and his collaborators used 3,000 particle traces found on a three-centimetre square of the photographic plate. An important step forward in their efforts to improve and develop the photographic method was taken in 1946, when Professor Powell and his collaborators reported on experiments with a new llford emulsion, called "C 2", whose properties excelled those of the half-tone emulsion in every respect. The traces of the particles appeared more clearly and the absence of disturbing background considerably increased the reliability of the measurements. It now became possible to make another attempt at solving the problem of discovering rare processes, and to charge the emulsions with other atoms for special investigations. The improved photographic method had the greatest importance for the study of cosmic radiation. When one considers that the photographic plates register continuously, whereas the Wilson chamber, as it were, discovers particles and processes only during the brief moments of exposure, it is easy to see that the photographic method offers great advantages over the Wilson chamber for these investigations. Plates with the new emulsion were exposed to cosmic radiation on Pic du Midi. 2.800 metres above sea level. During the study of these plates and of plates exposed at higher altitudes, up to 5,500 metres, a great number of isolated particle traces were found, as well as so-called "disintegration stars" with varying numbers of ramifications, originating from the disintegration of atomic nuclei in the emulsion. Analysis of these stars showed that some of them had been produced by a particle of small mass which had entered the emulsion, passed into an atomic nucleus, and caused its disintegration. A more detailed investigation showed that the active particle was a meson, which has a mass a few hundred times greater than that of the electron, and which was, in this case, negatively charged. Some cases of nuclear disintegration were observed in which slow mesons were ejected from the nucleus. Continued investigation of the plate material revealed other remarkable phenomena. In 1947, Powell Occhialini, Muirhead, and Lattes reported the discovery of mesons which at the end of their path give rise to secondary mesons. The analysis of the traces of primary and secondary mesons indicated the probable existence of two kinds of mesons having different masses, a theory which was vindicated by further experiments. The primary mesons were named (}mesons and the secondary mesons, μ-mesons. Preliminary determinations of the masses showed that the mass of the (}meson was greater than that of the μ-meson. The charge was equal to the electrical elementary charge. It would be impossible on this occasion to go into greater detail concerning the ingenious methods invented by the Bristol researchers for identifying the paths of the particles, or about the extensive work which was done to determine the relation between the masses of the (}mesons and μ-mesons, and to investigate their properties. I shall only review very briefly some of the most important conclusions regarding the mesons and their properties.

It was found in Professor Powell's laboratory that the mass of the (}meson was 1.35 times greater than that of the μ-meson, a relation which agreed closely with the value of 1,33 which the Berkeley researchers had determined for artificial mesons produced in their 184-inch cyclotron. The mass of the (}meson is said to be 286 times greater than the mass of the electron, and that of the μ-meson 216 times greater. The latter meson is identical with the one whose existence in cosmic rays had been previously established by American researchers. Both the (} and the μ-meson may be positively or negatively charged. The lifetime of the μ-meson has been found to be one millionth of a second, that of the (}meson one hundred times shorter. The (}mesons are unstable and disintegrate spontaneously into μ-mesons. The negative (}mesons easily enter into reciprocal action with the constituents of the atomic nucleus and at the end of their paths in the emulsion they are caught by atoms and give rise to the disintegration of both light and heavy atomic nuclei. Thanks to the introduction of a new emulsion which, unlike those mentioned above, is sensitive to electrons (the Kodak N.T.4 emulsion), Professor Powell showed in 1949 that the μ-mesons disintegrate at the end of their paths into one charged light particle and, probably, into at least two neutral particles.

Among Professor Powell's latest investigations I should mention his study of the -mesons, which have a mass about 1,000 times that of the electron. Their existence had been established earlier by various researchers, and more proof was gathered through the work at Bristol.

The introduction of the new electron-sensitive emulsions makes it probable that we may expect further important discoveries from Professor Powell's laboratory. One has been reported as recently as this year: the discovery of the neutral meson in cosmic radiation. The existence of this particle had been established earlier in the work with artificial mesons at Berkeley. Its lifetime has been found to be 100 million times shorter than the lifetime of the μ-meson, which is one-millionth of a second

Professor Powell. One of the many who have proposed you to the Nobel Committee as a candidate for the Physics Prize said, "His special claim to consideration is, in my view, the fact that he has shown that discoveries of fundamental importance can still be made with the simplest apparatus - in this case special nuclear emulsions developed under his general direction and microscopes". No one can dispute these facts. Through many years of purposeful work you have brought the photographic method to undreamt of perfection and have made it one of the most efficient aids of modern nuclear physics. The great variety of investigations into atomic processes which have been conducted with the photographic method at your laboratory have made it abundantly clear that after the introduction of your improvements this method has an uncontested position among the most important tools available to the nuclear physicist of our times. The great superiority and efficiency of your improved method as compared to other methods for the study of cosmic rays have been eloquently and convincingly confirmed by the sensational and significant discoveries made by yourself and your distinguished staff in regard to these rays and the nuclear processes caused by them. Your study of the mesons and your discoveries in this connection have borne new members to the family of elementary particles. I need not stress the extraordinary importance of your discoveries for research in nuclear physics, more particularly for our concept of nuclear energy and our knowledge of cosmic radiation.

I only wish to give expression to the sincere admiration and respect we physicists feel for your eminent work through which, in pursuance of great British traditions, you have enriched our field of knowledge with results of the greatest scientific value.

On behalf of the Royal Swedish Academy of Sciences I wish to congratulate you on your significant work and discoveries and to request that you receive your well-earned reward, the Nobel Prize in Physics for the year 1950, from the hands of His Majesty the King.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1950/press.html