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Nobel Prize in Physics 1927

Arthur Holly Compton **Charles Thomson Rees Wilson**

The Nobel Prize in Physics 1927 was divided equally between Arthur Holly Compton *"for his discovery of the effect named after him"* and Charles Thomson Rees Wilson *"for his method of making the paths of electrically charged particles visible by condensation of vapour"*.

RESEARCH INFORMATION:

The Royal Academy of Sciences has awarded this year's Nobel Prize in Physics to Professor Arthur Holly Compton of the University of Chicago for the discovery of the phenomenon named after him the Compton effect, and to Professor Charles Thomson Rees Wilson of the University of Cambridge for his discovery of the expansion method of rendering visible the tracks of electrically charged particles.

Professor Compton has won his prize by work in the field of X-radiation. Soon after Röntgen's discovery it became known that matter exposed to X-rays emits radiations of different character. Besides an emission of electrons, corresponding to the photoelectric effect known also in the optical region of radiation, there is also a secondary X-radiation. Even before the methods of X-ray spectrometry were known, these secondary X-rays were proved by the investigation of their absorption to be of a twofold nature. It was Barkla who, through his fundamental researches, proved that the secondary X-radiation consists partly in a scattering of X-rays, which he thought to have the same penetrability as the original radiation, and partly in a specific X-radiation which was characteristic of the chemical atom and which was more easily absorbed.

When X-rays fell upon matter with small atomic weight, as for example graphite, Barkla was not able to detect the mentioned characteristic X-radiation, but only a scattering; and consequently the secondary rays ought to have the same properties as the original X-rays. Barkla, however, in the course of his investigations of the absorption, had already been able to show that in this case also the secondary X-rays - at least partly - are more easily absorbed than the original radiation and therefore have a greater wavelength. Barkla thought this to be a new characteristic X-radiation.

This is the point where Compton comes in and affects the development of science. He made exact spectrometrical investigations of the secondary X-radiation from matter with small atomic weight: in other words, he undertook to investigate exactly the scattered X-radiation. After some preliminary work, he found an experimental method that gave results which were as exact as they were astonishing.

Using homogeneous X-rays - corresponding optically to monochromatic illumination, that is to say, to the use of a source of light that emits only one single spectral line - he found that the scattered radiation consists of two lines, one exactly the same as that of the source of rays, the other with a somewhat greater wavelength. This is the first evident manifestation of the Compton effect. Its reality was at first disputed, but of late years it has been well established and verified.

The change in wavelength soon proved to be independent of the nature of the matter used for scattering, while it varies with the angle between the incident and the scattered rays. Hence the phenomenon cannot be explained as a new characteristic radiation of the same nature as that hitherto known; and Compton deduced a new kind of corpuscular theory, with which all experimental results showed perfect agreement within the limits of experimental error.

According to this theory, a quantum of radiation is re-emitted in a definite direction by a single electron, which in so doing must recoil in a direction forming an acute angle with that of the incident radiation. In its mathematical dress this theory leads to an augmentation of the wavelength that is independent of the wavelength of the incident radiation and implies a velocity of the recoil electron that varies between zero and about 80% of the velocity of light, when the angle between the incident and the scattered radiation varies between zero and 180°.

Thus this theory predicts recoil electrons with a velocity generally much smaller than that of the above-mentioned electrons which correspond to the photoelectric effect. It was a triumph for both parties when these recoil electrons were discovered by Wilson's experimental method both by Wilson himself and, independently, by another investigator. Hereby the second chief phenomenon of the Compton effect was experimentally verified, and all observations proved to agree with what had been predicted in Compton's theory.

Quite apart from the improvements and additions that have been made to this theory by other investigators, the Compton effect has, through the latest evolutions of the atomic theory, got rid of the original explanation based upon a corpuscular theory. The new wave mechanics, in fact, lead as a logical consequence to the mathematical basis of Compton's theory. Thus the effect has gained an acceptable connection with other observations in the sphere of radiation. It is now so important that, in the future, no atomic theory can be accepted that does not explain it and lead to the laws established by its discoverer.

Finally, the fact deserves to be emphasized that the Compton effect has proved to be of decisive influence upon the absorption of short-wave electromagnetic - especially radioactive - radiation and of the newly discovered cosmic rays.

Professor Compton. Your discovery of the phenomenon known as the Compton effect has already proved so important that the Royal Academy of Sciences has awarded you a Nobel Prize, which I now ask you to receive from the hands of His Majesty.

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Professor Wilson has been awarded his prize for the discovery of a purely experimental method, which dates back from as long ago as 1911. It is based upon the formation of clouds, which develop when sufficiently moist air is suddenly expanded. The refrigeration caused by the expansion brings the temperature to sink below the dew-point, and the vapour is condensed into small drops, which form together visible clouds. In the first stage of condensation a droplet is always formed round a nucleus. The fact that an electrically charged particle acts as a nucleus in the formation of drops could, after the discovery of the corpuscular radiations, be concluded from an experiment that Helmholtz had, long before, made when he found that a stream of vapour loses its transparency in the vicinity of electrically charged objects.

After it had become known that electricity is conducted through gases by means of ions, and that ions are formed - or, in other words, gases are ionized - under the influence of X-rays or radioactive substances, the way lay open for Wilson to follow photographically the formation of droplets around electrically charged particles. Alpha and beta particles emitted by radioactive substances ionize the gases, and their tracks are marked by a formation of droplets. A suitable photograph of these droplets then gives a picture of the tracks of the ionizing particles.

The problem is a little more complicated when the nature and the details of the ionization caused by X-rays have to be analysed; and the perfect method for such investigations was not described until in a paper of 1923. The extremely delicate regulation of small-time intervals which is necessary in such researches is attained by the use of three pendulums of adjustable period, which are all released simultaneously. The pendulum which comes down first, opens a communication with a vacuum, and the resulting suction is used, by a mechanical device, to produce a sudden expansion of the gas that is being examined. The second pendulum releases an electric spark, which passes through an X-ray tube, oscillatory sparks being excluded; and thus the anticathode is brought to send an X-radiation of extremely short duration through the gas before the lenses of a stereoscopic camera. The third pendulum releases another electric spark, which passes through mercury vapour and momentarily illuminates the clouds. By means of sliding weights on the different pendulums, just as on an ordinary metronome, Wilson was able to bring it about that the X-rays were sent through the gas at the moment when the expansion was complete, and the illuminating spark just as long afterwards as was needed for a sufficient formation of droplets round the ions, but before the droplets had time to be dislocated by currents in the gas, which might have deformed the tracks visible on the photographic pictures.

Wilson's method attracted attention at first mainly as an elegant and popular method of demonstration. The formation of droplets by *x*-particles is so dense that the resulting cloud photographs show continuous white lines: and everybody was glad to recognize on these lines the sharp bendings which correspond to the sudden change of direction previously known. Along the beta-rays, on the other hand, are seen isolated droplets, and their tracks show a multitude of different types according to differences in initial velocity. For the investigation of such rays with a comparatively small velocity, the most suitable method is the excitation by the momentary X-radiation described above. Here there has been collected a very large photographic material, from which probably not all possible conclusions have yet been drawn, and to which Wilson has devoted assiduous work.

Of late years, new and scientifically important results have been attained which could not have been gained by other methods. The consequence of this is that the discovery, although it was made so long ago, satisfies the provisions for the award of the Nobel Prize. It would not be of much use to describe these results on this occasion, as the understanding of them presupposes full knowledge of the structure of the atom. I will merely call to mind that in 1923 Wilson gave the experimental proof of the existence of the recoil electron tracks that had been postulated by Compton for his explanation of the change in wavelength of scattered X-rays, and that his method has rendered possible the closer examination of these tracks.

Professor Wilson. Although a long time has elapsed since you discovered your elegant expansion method, the high value of your discovery has been greatly augmented both through your own assiduous investigations and through results obtained by others. The Academy is happy that an article in the Statutes allows it in such cases to reward even discoveries of comparatively old date; and I now ask you to receive the prize that you have won from the hands of His Majesty.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1927/press.html