Nobel Prize-Winner Tells of Discoveries

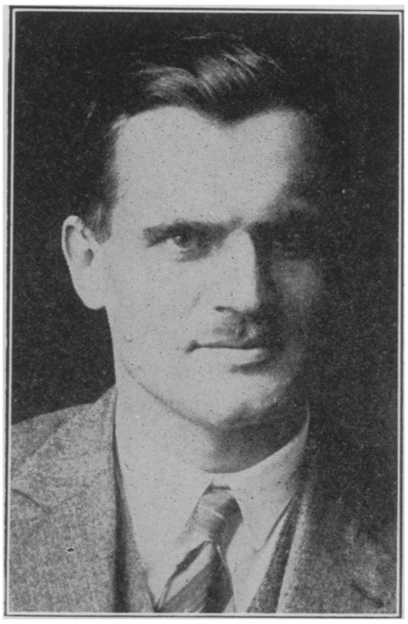
On Saturday, December 10, in Stockholm, Sweden, the Nobel Prize in Physics was awarded jointly to Dr. C. T. R. Wilson, of Cambridge University, England, and to Dr. Arthur H. Compton, of the University of Chicago. In the following article, written by Dr. Compton especially for Science Service, he summarizes the Nobel lecture which he gave when awarded the prize.

X-Rays as a Branch of Optics

By Arthur H. Compton

One of the most fascinating aspects of recent physics research has been the gradual extension of the familiar laws of optics to the very high frequencies of X-rays, until at present there is hardly a phenomenon in the realm of light whose parallel is not found in the realm of X-rays. Reflection, refraction, diffuse scattering, polarization, diffraction, emission and absorption spectra, photoelectric effect, all of the essential characteristics of light have been found also to be characteristic of X-rays. At the same time it has been found that some of these phenomena undergo a gradual change as we proceed to the extreme frequencies of X-rays and as a result of these interesting changes in the laws of optics we have gained new information regarding the nature of light.

It has not always been recognized that X-rays is a branch of optics. As a result of the early studies of Roentgen and his followers it was concluded that X-rays could not be reflected or refracted, that they were not polarized on traversing crystals, and that they showed no signs of diffraction on passing through narrow slits. In fact, about the only property which they were found to possess in common with light was that of propagation in straight lines. Many will recall also the heated debate between Barkla and Bragg, as late as 1910, one defending the idea that X-rays are waves like light, the other that they consist of streams of little bullets called "neutrons." It is a debate on which the last word has not yet been said!



ARTHUR HOLLY COMPTON
(Biographical Sketch on Next Page)

Though Roentgen in his early experiments was unable to find either refraction or reflection of X-rays, unsuccessful attempts to detect such effects were persistently made until 1919 when Stenstrom in a study of the spectra of soft X-rays noticed certain peculiarities in these spectra which he ascribed to the refraction of the X-rays in the crystals that he used. This suggestion of refraction was confirmed by experiments by Duane and Siegbahn in which they noticed similar effects with ordinary X-rays. It was found that for the X-rays the index of refraction of a crystal is less than that of air, contrary to what is found in the case of light. This suggested the possibility of obtaining total reflection as X-rays go from air into glass, similar to the total reflection of light at the surface of a prism. The discovery of such total reflection opened the way to new and more precise measurements of the refraction of X-rays and made possible studies of the spectrums of these rays using diffraction gratings similar to those used with light.

These experiments on the refraction and reflection of X-rays have afforded us what is perhaps our best quantitative tests of the classical theory of optical refraction and it has given us our most accurate method of counting the number of electrons in atoms.

X-Rays Like Light

Perhaps the property of light which is most closely connected with its wave characteristics is that of diffraction or interference. The first successful attempts to observe the diffraction of X-rays were perhaps those of Walter and Pohl, whose experiments when interpreted by Koch and Sommerfield, showed rather definite bending of the X-rays as they passed through narrow slits. It was this work which suggested to Laue his remarkable experiment of using crystals as diffraction gratings for X-rays. The manner in which these experiments of Laue's led to precise measurements of X-ray wave-lengths and to a knowledge of crystal structure more precise than we have dreamt possible, is well known.

There is, however, another diffraction phenomenon which during the last few years has become important. It is that of the diffraction of X-rays by gratings ruled on polished surfaces. These experiments have afforded us our most direct method of measuring X-ray wave-lengths and have during the last year enabled us to study the complete spectrum from visible light through the ultraviolet and soft X-ray regions into the region of X-rays. It would take a bold man indeed to suggest, in view of this recent work, that there is any essential difference in quantity between the X-rays and light.

A second characteristically wave property of light is its polarization. Though Roentgen's early attempts to polarize X-rays by means of prisms, as light is polarized, were without success, Barkla some twenty years ago succeeded in polarizing X-rays by scattering them at right angles much as sunlight is polarized when scattered as blue light from the sky. More recent experiments have shown that under suitable conditions this polarization of the X-rays is complete at 90° with the primary beam in exact accord with the predictions of the electromagnetic wave theory of radiation.

The Compton Effect

The phenomena which we have been considering are those in which we find with X-rays results entirely in accord with our expectations if they obey the same laws as ordinary light. Within the last few years, however, phenomena connected with the scattering of X-rays has become prominent in which gradually increasing departures from the optical laws appear as we go to the very high frequencies of X-rays. I refer to the change of wave-length of the X-rays when they are scattered. The experiments showing this change of wave-length are too well known to require description. It is found that a part of the scattered rays are of the same wave-length as the primary radiation but that a part which becomes increasingly prominent for the higher frequencies is of increased wave-length.

Attempts to account for this phenomenon on the basis of waves

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X-Rays and Optics

(*Continued from page* 387)

have not been successful. Simple explanation is, however, found in the assumption that the X-rays consist of rapidly moving particles which we may call photons which are deflected by electrons. On this view when a photon bounces from an electron the electron recoils leaving the photon with less energy than before. This reduction in energy corresponds to an increase in wave-length which is found to be in exact accord with experimental measurements.

When this theory was first proposed no electrons recoiling from scattered X-rays were known, but they were discovered by Wilson and Bothe within a few months after their prediction. Now we know that the number, energy and spatial distribution of these recoil electrons are in accord with the predictions of the photon theory. The final test of the theory consisted in following a photon after its collision with one electron until it collided with a second. Photographs showing the paths of the electrons recoiling from such a photon made it possible to follow its path and to show that energy and momentum were conserved when it collided with the first electron. Unless there is some fault with this experiment it would seem to show definitely that the X-rays consist of minute particles.

Waves or Corpuscles?

Thus we see that as a study of the scattering of radiation is extended into the very high frequencies of X-rays, the manner of scattering changes. For the lower frequencies the phenomena could be accounted for in terms of waves. For these higher frequencies we can find no interpretation of the scattering except in terms of the deflection of corpuscles or photons of radiation. Yet it is certain that the two types of radiation, light and X-rays, are essentially the same kind of thing. We are thus confronted with the dilemma of having before us convincing evidence that radiation consists of waves, and at the same time that it consists of corpuscles.

It is these changes in the laws of optics when extended to the realm of X-rays which have been in large measure responsible for the recent revision of our ideas regarding the nature of the atom and of radiation.

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PHYSICS

Latest Nobel Laureate

(Picture of Prof. Compton on Page 387)

When it comes to winning Nobel prizes in physics, few, if any, institutions can equal the record of the Ryerson Laboratory of Physics at the University of Chicago. The first came in 1907 to Prof. A. A. Michelson. Then, in 1923, Prof. R. A. Millikan received the prize, after he had left Chicago to go to the Norman Bridge Laboratory in Pasadena, but for work done at the Ryerson Laboratory.

Now, the third award comes with the announcement that Dr. Arthur H. Compton shares the prize this year with Prof. C. T. R. Wilson, of Cambridge University. It is very appropriate that these two should be paired, for it is Prof. Wilson's method of photographing the tracks of moving atoms by their trail of fog that Dr. Compton has employed in his work.

Dr. Compton belongs to a physical family, for his older brother, Prof. Karl T. Compton, professor of physics at Princeton, is also one of America's leading physicists.

It was in Wooster, Ohio, that Dr. Compton first saw the light of day on September 10, 1892, and it was from Wooster University that he graduated in 1913 with a B. S. After graduate work at Princeton and teaching and research work at Wooster, Princeton, Minnesota, the Westinghouse research laboratory and Washington University, St. Louis, Dr. Compton became professor of physics at Chicago, where he is actively at work. This year he is vice-president of the American Association for section B, a position which his brother held in 1925.

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