ISSN:2249-5347

IJSID

International Journal of Science Innovations and Discoveries

An International peer
Review Journal for Science

Nobel Prize in Physics 1914

Max von Laue

The Nobel Prize in Physics 1914 was awarded to Max von Laue *"for his discovery of the diffraction of X-rays by crystals"*.

RESEARCH INFORMATION:

Seldom indeed can a discovery in the field of physics have given rise to such intensive research work as did that of Röntgen in 1896, when he proved the existence of a new form of rays which had hitherto been unknown and which, owing to their remarkable characteristics, have since achieved a position of the greatest importance, not only in the field of pure physics but also in connection with research work throughout the other sciences.

Notwithstanding the considerable number of tests which have been carried out since their discovery and directed toward investigation of the true nature of X-rays, it was not until over a decade had passed that their true nature had finally been elucidated.

Already during the first tests it was established that not even the strongest magnetic fields were able to alter the direction of the rays. It was equally impossible to prove the existence of a refraction on transfer of the rays from one medium to another. If the X-rays were of a corpuscular nature they could not, therefore, be carriers of an electrical charge, as is the case with other known rays of corpuscular nature. If, therefore, we wish to disregard matter which has no electrical charge, it is necessary to assume that the particles, whose motion is characteristic for the X-rays, bear two charges of opposite sign, one of which neutralizes the other. On the other hand, from the fact that there was no evidence of refraction of the X-rays, it was possible to assume that, should they consist of a transverse wave motion - as is the case with light waves - the relevant wavelength would have to be very small, as for very small wavelengths, according to the theory of dispersion of light, the refractive index would approach unity.

After hurriedly discarding an hypothesis which had been expounded initially, according to which X-rays were believed to consist of longitudinal wave motions in ether, opinions as to their actual nature were divided according to the above two alternatives. Nevertheless an objective presentation could only describe them as a type of impulse of an unknown nature.

On the basis of an hypothesis expounded as early as 1896 by Stokes and Wiechert this impulse was believed to consist of a disturbance which occurs in the ether when the cathode-ray particle, i.e. a forward-rushing electron, is impeded on colliding with molecules of matter. This disturbance or impulse was believed to propagate in all directions at the speed of light from the ether surrounding the electron. In each part of the space this disturbance was maintained for a period of identical duration to that in which the electron was impeded. This period of time, multiplied by the speed of light, was described as the impulse width, a quantity which, if the nature of the X-rays were the same as that of the light rays, would coincide with the wavelength.

According to that theory the X-ray impulse, which originates perpendicular to the cathode-ray bundle by which it is excited, is alleged to be completely polarized. The evidence of this type of polarization was first produced by Barkla in 1905, but, contrary to the theory, the polarization was not complete but only partial. While it was possible to explain the causative factors of this aberration the characteristics of the polarization were not adequate to prove the existence of a transverse undulation.

Once Dorn had succeeded, in 1897, in determining the fraction of the energy of the impeded electrons which is converted to X-rays, W. Wien was able to calculate the impulse width which, according to his figures, amounted to approximately 10^{-10} cm, or only one hundred-thousandth of the shortest known wavelengths of light. The short impulse width thus determined could explain the lack of success with previous diffraction tests which had been carried out on slits with X-rays, for even with the narrowest slit the diffraction phenomenon, which is produced by such small impulse widths or wavelengths, would have to lie just about at the limits of possible observation. And it may, in actual fact, only be said even of the most accurate of these tests conducted by Walter and Pohl that they render diffraction highly probable. From the research carried out by these scientists it would meanwhile seem to follow that the upper limit for the impulse width of X-rays lies at 4 x 10

This was the situation when von Laue placed a research medium of the highest import at the disposal of science by virtue of his epoch-making discovery of the interference of X-rays and, at the same time, proved that X-rays, as is the case with light rays, consist of progressive transversal waves.

Previous research had indicated, as is mentioned in the foregoing, that it was highly probable that, if X-rays are wave motions of the same type as light rays, then their wavelengths would have to be of an order of 10^{-9} cm. In order to obtain clear interference phenomena of the same type as those which are caused when light rays pass a grating it was necessary for the distance between the grating slits to be of an order of 10^{-8} cm. But this is approximately the distance between the molecules of a solid body and it was in this manner that von Laue arrived at the idea of employing, as a diffraction grating, a solid body with regularly-arranged molecules, e.g. a crystal. As early as 1850 Bravais had introduced into crystallography the assumption that the atoms composing the various crystals are arranged in regular groups, so-called three-dimensional lattices or space-lattices, whose constants could be calculated with the aid of crystallographic data.

However, the theoretical basis of a space-lattice was unknown and thus it was first necessary for von Laue to develop this theory if else the investigation were to have a value. This he did mainly according to the same approximations as those conventional to the science of optics as applied to normal one-dimensional lattices.

Von Laue left the execution of the experimental work in the hands of W. Friedrich and P. Knipping. The apparatus which they employed consisted of a lead box into which they admitted a thin bundle of X-rays which they directed so as to fall upon a precisely oriented crystal. Sensitized film was positioned both behind and at the sides of the crystal. Already the preparatory tests showed that the intensity maxima which had been anticipated by von Laue became evident in the form of blackened spots on the film positioned behind the crystal.

From the grouping shown by these intensity maxima in accordance with the requirements of the theory, as established, for such photograms of various crystals and from the degree of clarity with which they have been reproduced, it follows that they are an interference phenomenon. Absorption tests have shown that the rays which give rise to the points of interference are actually X-rays, and from this von Laue has deduced with a high degree of certainty that the X-rays which cause intensity maxima on irradiation of a crystal have the character of a wave motion. However, the same is required also for those rays employed for irradiation purposes, for, as he says, were they of a corpuscular nature, coherent oscillations could only arise from those atoms set into motion by the identical corpuscle and these atoms would have to form together one whole agglomerate whose dimensions would tee largest in the direction of radiation. However, contrary to what was indicated in the experiment, this would result in the intensity maxima consisting of irregular concentric circles.

As a result of von Laue's discovery of the diffraction of X-rays in crystals proof was thus established that these light waves are of very small wavelengths. However, this discovery also resulted in the most important discoveries in the field of crystallography. It is now possible to determine the position of atoms in crystals and much important knowledge has been gained in this connection. We can anticipate further discoveries of equal note in the future. It is thus rendered likely that experimental research into the influence of temperature upon diffraction will provide the solution to the question of a zero-point energy, or will at least be of some assistance in arriving at a solution to this problem, as the temperature factor assumes a different value according to whether a zero-point energy exists or not. However, the direct results of this discovery of diffraction are of no less importance: it is now possible to subject the X-ray spectra to direct examination, their line spectra can even be photographed, and science has thus been enriched by a method of research whose full implications can not yet be fully appreciated.

If it is permissible to evaluate a human discovery according to the fruits which it bears then there are not many discoveries ranking on a par with that made by von Laue. If one reflects further on the fact that only a few years have passed since his discovery was first published it may surely be said that, when awarding the Nobel Prize for Physics, the Royal Academy of Sciences will presumably seldom, if ever, be in a position of such close agreement with the letter of the Testament as on this occasion in deciding to award the Nobel Prize for Physics for the year 1914 to Professor Max von Laue, for his discovery of the diffraction of X-rays in crystals.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1914/present.html