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Nobel Prize in Physics 1919

Johannes Stark

The Nobel Prize in Physics 1919 was awarded to Johannes Stark *"for his discovery of the Doppler effect in canal rays and the splitting of spectral lines in electric fields"*.

RESEARCH INFORMATION:

The Royal Academy of Sciences has decided to award the Nobel Prize in Physics for 1919 to Dr. Johannes Stark, professor in the University of Greifswald, for his discovery of the Doppler effect in canal rays and of the splitting of spectral lines in electric fields.

It is only rarely that the study of a physical phenomenon has led to such a brilliant series of important discoveries as that which follows the conducting of an electrical current through a rarefied gas. As long ago as 1869 Hittorf discovered that if a low pressure is set up in a discharge tube, rays are emitted from the negative electrode, the so-called cathode. Although invisible to the eye, they can nevertheless be observed through certain effects peculiar to them. The continued study of these cathode rays, in which Lenard in particular earned great merit, showed that they are composed of a stream of negatively charged particles, the mass of which amounts only to 1/1,800 of the mass of the hydrogen atom. We call these minute particles electrons, and gradually one of the principal theories of modern physics grew from the study of the properties of electrons and of their relationship with matter. The electron theory with its concept of the constitution of matter has become of radical importance to both physics and chemistry.

When cathode rays strike an object, this becomes the source of a new radiation, namely that discovered by Röntgen in 1895 and named by him X-rays, the study of which has led to so many important results for major branches of science, not only within physics. Through von Laue's discovery of the diffraction of X-rays in crystals it was demonstrated that these rays are light waves of very short wavelength. It is now even possible to photograph the spectra of these rays, and science has by this been enriched with a means of research the implications of which cannot yet be fully realized.

Von Laue's discovery also occasioned important discoveries in the field of crystallography. It is possible, now that W.H. Bragg and his son have worked out theoretic and experimental methods for that purpose, to determine the positions of the atoms in crystals. By these methods a whole new world has been opened up, and has already been partly explored.

Of not less importance was Barkla's discovery in the year 1906 that every chemical element when irradiated with X-rays emits an X-ray spectrum, characteristic of the element in question. This discovery has become of outstanding importance for the theoretical study of the structure of the atom.

In the year 1886 Goldstein discovered a new kind of rays in discharge tubes containing rarefied gas, the study of which has become extremely important to our knowledge of the physical properties of atoms and molecules. In view of the manner of their formation Goldstein called them canal rays. It was proved by the research of W. Wien and J.J. Thomson that the majority of these are composed of positively charged atoms of the gas in the discharge tube, which move along the beam at a very high velocity.

In their course along the beam these canal-ray particles are continually colliding with the gas molecules which are contained in the tube, and thus it may be expected that light is emitted, if the kinetic energy is sufficiently great. As long ago as 1902 Stark predicted that the moving canal-ray particles thus become luminous, and that consequently

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the lines in the spectrum emitted by them must be displaced to the violet end of the spectrum if the rays are sighted approaching the observer. This takes place in the same way as the displacement of the lines in the spectra of those stars which are moving towards us, and as this displacement, the so-called Doppler effect, increases with the velocity of the light source, it must thus also be possible to determine the velocity of the canal-ray particles.

In 1905 Stark succeeded for the first time in detecting this phenomenon in a canal-ray tube containing hydrogen.

Beside each of the single hydrogen lines belonging to the familiar, so called Balmer series, a new, broader line appeared, which lay beside the original line, on the violet side of the spectrum if the canal rays were observed approaching the observer, but on the red side of the spectrum if observed from behind. The effect mentioned here has been established for the canal rays of all chemical elements which, in addition to hydrogen, have been investigated in this respect.

This discovery, by which a Doppler effect was recorded for the first time in the case of a terrestrial light source, was instrumental in the proof that canal-ray particles are luminous atoms, or atomic ions. The further study of the Doppler effect in their spectra, which has been pursued principally by Stark and his pupils, has led to extremely important results, not only concerning the canal rays themselves, their formation, etc., but also concerning the nature of the different spectra which one and the same chemical element can emit in different circumstances.

In the course of an investigation of canal rays in a tube containing hydrogen gas, which passed through a strong electric field, Stark observed, in 1913, a broadening of the lines in the spectrum of the hydrogen. A more thorough examination of this broadening showed that the lines decomposed into several components with characteristic polarization conditions. Although this splitting can best be observed in canal rays, it has nevertheless nothing to do with the movement of the atoms, but depends solely on the fact that these are present in an extremely strong electric field.

In this, a discovery was made analogous to Zeeman's discovery of the splitting of serial lines by means of an extremely strong magnetic field, which was also in its time crowned with the Nobel Prize by this Academy.

This splitting of lines in electric fields has been detected and measured by Stark in the line spectrum not only of hydrogen, but also of that of a great number of other substances, and the result of these investigations was that (the effect named after him turned out to be in several respects quite different from the Zeeman effect, and that thus) the optical dynamics of the atoms alters, under the influence of an electric field, in a manner quite different from that under the influence of a magnetic field.

The effect discovered by Stark has become extraordinarily significant for modern research into the structure of atoms, and has opened up new fields for the study of the effect of atomic ions on each other and on molecules. The extremely complicated conditions which this effect manifests in the spectral series of hydrogen and of helium were successfully explained by a theory which forms one of the strongest pillars on which the modern concept of the internal structure of the atom rests.

In view of the great significance which Stark's work so obviously has for physical research within various fields of great importance, the Royal Academy of Sciences considers it well warranted that the Nobel Prize in Physics for 1919 should be bestowed on this scientist.

Professor Stark. Our Academy of Sciences has awarded you the Nobel Prize in Physics for 1919 in recognition of your epoch-making research into the so-called Doppler effect in canal rays, which has given us an insight into the reality of the internal structure of atoms and molecules. The Nobel Prize relates also to your discovery of the splitting of spectral lines in electric fields - a discovery which is of the greatest scientific importance.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1919/press.html