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Nobel Prize in Physics 1917

Charles Glover Barkla

The Nobel Prize in Physics 1917 was awarded to Charles Glover Barkla *"for his discovery of the characteristic Röntgen radiation of the elements"*.

RESEARCH INFORMATION:

When X-rays fall on any substance, whether solid, liquid, or gaseous, they cause a secondary radiation. That was discovered by Sagnac in 1897 and it has since then been studied by a long series of investigators. Professor Barkla of Edinburgh, however, has carried out the most fundamental and exhaustive researches into the nature of this radiation, and in doing so he has discovered a new and unanticipated phenomenon, which has turned out to possess the utmost importance for physical investigation

The secondary radiation consists of two varieties of radiation wholly different from each other. One is a corpuscular radiation of the same character as cathode rays and as the analogous beta-rays of radioactive substances, being an emission of electrons. The other, on the contrary, is of the same character as X-rays

Barkla has made a long series of very careful investigations into the nature of the latter of the two types of radiation. In the first place he discovered that there are two different kinds of X-rays in the secondary radiation. The absorption coefficients of one of these two

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varieties are the same as those of the incident X-rays. Thus the rays have the same penetrability as the primary rays, and, as they prove in other respects to have the same qualities as the primary rays, they must be regarded as a diffused primary radiation.

The intensity of this diffuse radiation varies in different directions in relation to that of the incident primary radiation. By measuring the distribution of intensity of the diffuse radiation, Barkla was able to determine the total emission of a series of substances under varying conditions. One very important result among others that his investigations led to, enabled Barkla at an early stage to estimate approximately the number of electrons contained in an atom.

The other variety of X-rays is wholly independent of the character of the incident radiation. Barkla showed that this radiation is homogeneous, that its absorption coefficient is not dependent on the incident radiation, but is determined by the irradiated substance. Further, he made the important discovery that the character of the rays is solely dependent on the qualities of the atoms constituting the substance, irrespective of their grouping and influence upon each other, that is to say, independent of the chemical composition of the substance. Every chemical element yields a secondary radiation that is characteristic of that element. Hence Barkla named this variety of radiation the characteristic X-radiation.

This variety of radiation may be most conveniently studied in elements of relatively high atomic weight, for in them it is stronger than the diffuse radiation. The characteristic radiation, however, being, in contrast to the diffuse radiation, perfectly homogeneous, can be distinguished from the latter, and thus Barkla could trace the characteristic radiation down to elements of the atomic weight of 27.

The characteristic radiation is furthermore, in contrast to the diffuse radiation, wholly unpolarized and is not dissymmetrical in respect to the direction of incidence of the primary radiation, but spreads uniformly in all directions.

As the characteristic radiation originates from X-rays, the emission of this radiation must be accompanied by an absorption of X-rays. For this reason Barkla made a very thorough investigation of the absorption of X-rays by various substances. The result was that all such factors as density, temperature, state of aggregation and chemical composition proved to be without essential importance. The qualities of the atoms alone determine the amount of the absorption. The absorption is furthermore selective, and, just as with regard to light, those rays are by preference absorbed that the substance emits at the same temperature, so it is here, the atoms absorbing by preference those X-rays that they themselves emit in the form of characteristic radiation.

Another striking resemblance between light and the X-rays has been discovered by Barkla. Just as, in agreement with Stokes' law, fluorescence can only be generated by light of a higher frequency, so too the characteristic radiation requires for its origination a greater penetrability of the primary rays.

Barkla's discovery that two domains of differing hardness are to be differentiated in the characteristic radiation, is of fundamental importance as regards the modern conception of the structure of atoms. Barkla has named the two domains the K-series and the L-series respectively. Thus every chemical element, when irradiated by X-rays, emits two rays of different penetrability, that is to say, every element can by fluorescence emit an X-ray spectrum of two lines or line-groups, the so-called K-series and L-series. Of these, the K-series have the greater penetrability. Barkla succeeded in following the K-series from calcium to cerium, the L-series from silver to bismuth.

If these rays are defined, for instance, in terms of their absorption in aluminium, the said absorption for rays belonging to one and the same series proves to be, approximately, a linear function of the atomic weight of the element that emits the radiation. By arriving at that conclusion Barkla had on the one hand furnished the most indisputable proof that every chemical element possesses a characteristic X-ray spectrum of its own, while on the other hand it was made manifest by these investigations that the said characteristic spectra, in contrast to all other spectra hitherto known, do not display any periodic qualities in connection with the places of the elements in the periodic system.

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Barkla's discovery of the characteristic X-radiation has proved to be a phenomenon of extraordinary importance as regards physical research, a fact which has been made increasingly manifest by the subsequent researches of other investigators.

The discovery of the diffraction of X-rays in crystals gave a means of measuring their wavelengths, and since then the further investigation of the K-series and the L-series has yielded results of fundamental importance as regards our conception of the inner structure of atoms. It would, however, carry us too far to enter upon that topic here. Suffice it to say that those investigations have shown that it is the electrical charge of the nucleus of the atom that determines its place in the periodic system, not, as has been hitherto assumed, its atomic weight. The former is in general half the latter, but the divergences from the rule are due to irregularities in the distribution of the atomic weight amongst the elements, the charge of the nucleus being the factor that determines the chemical attributes of the atom. It has also been possible to establish the fact that of the chemical elements there are now not more than six that are unknown. Barkla's discovery of the characteristic X-radiation of the elements reveals a phenomenon of the utmost importance for the study of the inner structure of atoms and has already led to such far reaching and significant conclusions, that it may with justice be asserted that no such important discovery in spectroscopy has been made since that of the discontinuous spectra from flames and electric sparks and the subsequent differentiation of those spectra in series, line and band spectra.

In consideration of this fact the Royal Swedish Academy of Sciences decided to award the 1917 Nobel Prize in Physics to Professor Barkla for his discovery of the characteristic X-radiation of the elements.

<u>For more details please visit:</u>

http://www.nobelprize.org/nobel_prizes/physics/laureates/1917/present.html