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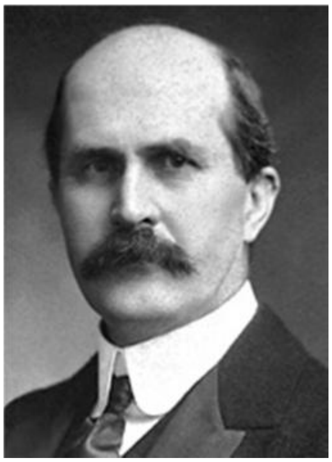
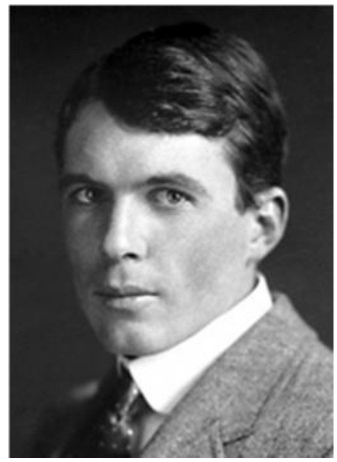
Nobel Prize in Physics 1915



Sir William Henry Bragg



William Lawrence Bragg

The Nobel Prize in Physics 1915 was awarded jointly to Sir William Henry Bragg and William Lawrence Bragg *"for their services in the analysis of crystal structure by means of X-rays"*

RESEARCH INFORMATION:

Von Laue's epoch-making discovery of the diffraction of the X-rays in crystals, on the one hand established wave motion as the essential quality of those rays and, on the other, afforded the experimental proof of the existence of molecular gratings in the crystals. The problem, however, of calculating the crystal structures from von Laue's formulae was an exceedingly complicated one, in as much as not only the space lattices, but also the wavelengths and the intensity-distribution over the various wavelengths in the spectra of the X-rays, were unknown quantities. It was consequently a discovery of epoch-making significance when W.L. Bragg found out that the phenomenon could be treated mathematically as a reflection by the successive parallel planes that may be placed so as to pass through the lattice points, and that in this way the ratio between the wavelengths and the distances of the said planes from each other can be calculated by a simple formula from the angle of reflection.

It was only by means of that simplification of the mathematical method that it became possible to attack the problem of the crystal structures, but to attain the end in view it was further necessary that the photographic method employed by von Laue should be replaced by an experimental one, based on the reflection principle, which admitted of a definite, even though at first unknown, wavelength being made use of. The instrument requisite for the said purpose, the so-called X-ray spectrometer, was constructed by Professor W.H. Bragg, W.L. Bragg's father, and it has been with the aid of that instrument that father and son have carried out, in part conjointly, in part each on his own account, a series of extremely important investigations respecting the structure of crystals.

If a number of cubes are laid on and beside each other in such a way that one cube face coincides in every case with the face of an adjoining cube, whereby consequently eight vertices always meet in one point, those angular points give a visual picture of the lattice points in the so-called simple cubic lattice. If again a lattice point is placed so as to coincide with the central point of each cube face, the so-called face-centred cubic lattice is obtained, whereas the centred cubic lattice has one lattice point in every cube-centre. With the exception of these three cases there is no cubic lattice that fulfils the condition that parallel planes placed in any direction whatever so as to pass through all the lattice points, shall also be at a constant distance from each other. The space lattice in the regular or cubic system must therefore coincide with one of those three, or constitute combinations of them. In such lattice combinations, on the other hand, in which the condition just mentioned is not fulfilled, where consequently parallel planes placed to pass through all the lattice points in certain directions are not equidistant, that circumstance is revealed by an abnormal intensity distribution among spectra of different orders, when the reflection takes place by those planes.

From crystallographical data it is always known how the face of a cube is situated in any given regular crystal, and there is consequently no difficulty in fixing the crystal on the spectrometer table in such a way that the reflection shall take place by planes with any prescribed orientation.

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The rays falling on the crystal were produced by X-ray tubes, platinum being at first used for the anticathode. The characteristic X-radiation of the metals consists, as is well known, of a few strong lines or narrow bands, and the very first experiments with the spectrometer revealed the X-radiation that is characteristic of platinum. However, in the research undertaken to find out the nature of complicated space lattices, in which an abnormal intensity distribution among spectra of varying orders constitutes one of the most important of the results observed, it soon proved desirable to have available an X-radiation of approximately half the wavelength of the strongest platinum-line. From theoretical considerations W.H. Bragg regarded it as probable that a metal whose atomic weight was somewhere near the figure 100, would give a characteristic radiation of the desired wavelength. Accordingly anticathodes of palladium and rhodium were produced, which fully answered the purpose in view, so that spectra ev en of the fifth order could be obtained and measured. In order to take practical advantage, however, of those results, it was essential to have a method for calculating the intensity in the case of a complicated space lattice, that would prove simpler than the one given by von Laue's theory, and W.L. Bragg developed one.

The above is a brief sketch of the methods discovered by the two Braggs for investigating crystal structures. The results of their investigations embrace a large number of crystals belonging to various systems and can only be cursorily summarized in this place.

To begin with, the two investigators applied themselves to the simplest types of the regular system, represented by the alkaline haloid salts. It then proved that potassium bromide and potassium iodide showed the spectra that are characteristic of a face-centred cubic lattice, while the spectra of potassium chloride represented a simple cubic lattice, sodium chloride occupying an intermediate position. As it must be assumed, on the strength of the analogy of these salts, both in a chemical and a crystallographical sense, that they are possessed of a corresponding space lattice, which could also be corroborated in another way, it was proved by those researchers that the lattice of the crystals in question consists of two face-centred cubic lattices corresponding to the two atoms, which interpenetrate in such a way that they together constitute one single cubic lattice.

From these investigations it follows that a metal atom in the crystals of the alkaloid salts is situated at one and the same distance from the six haloid atoms nearest to it, and vice versa - a relationship that was found to prevail, mutatis mutandis, in all the crystals examined. That means the exceedingly important discovery, both for molecular physics and chemistry, that the crystals consist of atomic lattices and not, as has been always imagined, of molecular ones.

Two face-centred cubic lattices can also interpenetrate in such a way that every point belonging to the one lattice is at the centre of gravity of a tetrahedron whose vertices are points belonging to the other lattice. That structure was found by the two Braggs in the diamond, and afforded an experimental support for the tetrahedral arrangement that chemists postulate for the four-coordinate carbon. On the other hand, the explanation became evident of why crystallographers have not been able to agree regarding the class in the regular system to which the diamond should be referred.

It would carry us too far and be quite too complicated a proceeding to give an account here of the further investigations into the space lattices of the crystals. It will suffice to add that, in the course of their investigations, the two Braggs have also discovered important relations between the amplitude and the phase difference of the diffracted rays on the one hand and the atomic weights on the other, and have also shown experimentally the influence of heat on the space lattice.

Finally it may be mentioned that the two investigators have also determined the wavelengths of the X-rays and the distances between the successive planes placed to pass through the lattice points with such exactitude, that the error, if any, is probably a t most some few units per cent and is more due to the general physical constant entering into the calculations than to the measurements themselves.

Thanks to the methods that the Braggs, father and son, have devised for investigating crystal structures, an entirely new world has been opened and has already in part been explored with marvellous exactitude. The significance of these methods, and of the results attained by their means, cannot as yet be gauged in its entirety, however imposing its dimensions already appear to be. In consideration of the great importance that these methods possess for research in the realm of physics, the Swedish Royal Academy of Sciences decided that the 1915 Nobel Prize in Physics should be divided between Professor W.H. Bragg and his son W.L. Bragg, in recognition of their services in promoting the investigation of crystal structures by means of X-rays.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/physics/laureates/1915/present.html