The two Braggs, Leeds in 1912, and the birth of Structural Crystallography*

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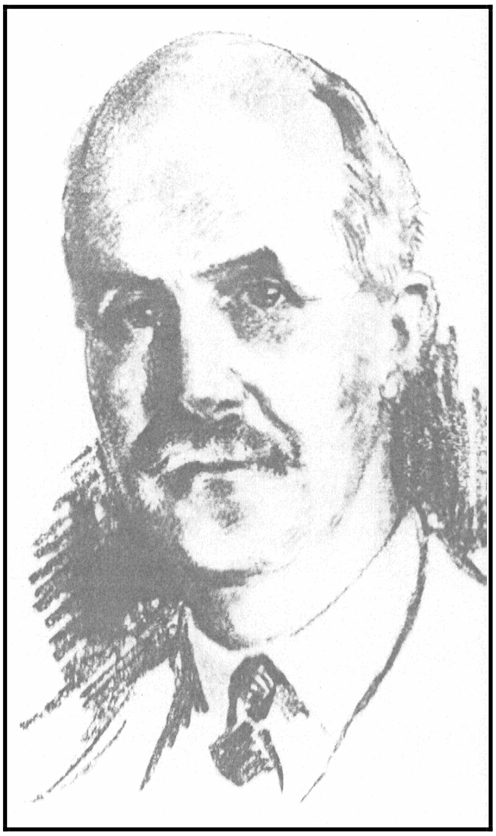
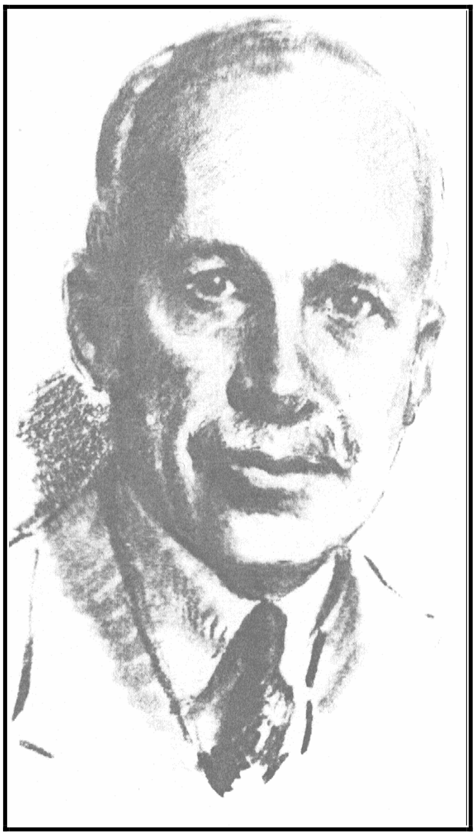


Sir William Henry Bragg
1862 - 1942



Sir William Lawrence Bragg
1890 - 1971

It was Max von Laue, in München, who had the supreme intuition (in mid-1912) that X-rays might be diffracted by crystals. He was right, and won the Nobel Prize for it. He also set out the famous Laue equations; but then, he left the matter. The physics of the phenomenon had, of course, been very neatly tied up. It was the Braggs, at Leeds, a few months later,

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who realised that X-ray diffraction was a key to a knowledge of the internal structure of crystals.

It is common knowledge that sodium chloride was the first crystal structure to be determined, and that its solution, along with the other alkali halides, was greatly assisted by the ideas of Pope and Barlow. But how, exactly, did the Bragg Equation get invented? Eighty four years after the event none of the details of that crucial advance in crystallography are as clear as we would like, but it seems that what happened was something like this:

Both the Braggs - father (WH) and son (WL) - were fascinated by the question, Were X-rays really waves, not particles? WH, who had been in Leeds already for three years (as Cavendish Professor of Physics) had the service of an excellent workshop; X-rays were available in his laboratory, so the experiments of Laue, Friedrich and Knipping were easily repeated. Meanwhile, WL, who had newly graduated in Maths and Physics at Cambridge, was a research student in Cambridge, under J. J. Thompson; but he joined his father whenever possible, in the vacations. On holiday, in the summer of 1912, they began discussing Laue’s discovery; soon after, they started their own experiments. Back in Cambridge after the vacation, WL studied Laue’s photographs further ... and it was there that he then had his brain wave.

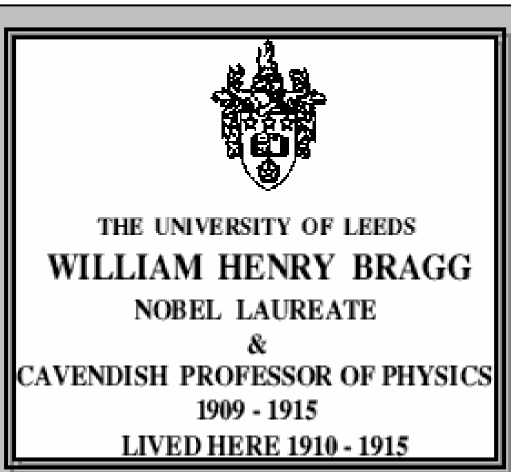
Young (22), independent, full of ideas, and with his University Physics lectures still fresh in his mind, WL remembered C.T.R. Wilson’s lecture course on optics, particularly CTR’s treatment of optical diffraction by a grating. CTR had shown that a “form-less pulse” (today, we would say, some white radiation) is split up by a grating into its component wavelengths, each emerging in its own geometrically determined direction; for a line grating the directions could be specified by equations of the type, n? = asin(?).

With these ideas in his mind he also recalled the well-known Huygens construction for the reflection of waves by the points of a plane surface. As soon as reflection was thought of, WL found that it explained the Laue pictures at once. (He especially liked its explanation of the elliptical shape of the Laue spots.) He then checked his idea experimentally with a piece of mica (it was CTR's suggestion to use something like that) since mica must have well-marked planes of atoms, because it cleaves so well. Sure enough, the mica behaved just like a mirror. WL took his photographic plate, still wet from the fixer solution, down to JJ's room to show him, and JJ was quite excited by it. So, with reflection now as the basic concept, the Bragg equation followed almost automatically:

$$n? = 2d\sin(?)$$

(Of this Bragg Law, WL wrote later that it was an easily earned honour to have it named after him because, after all, it was "merely the familiar relation giving the colours reflected by thin films".) Once having such a simple key to the interpretation of diffraction, WL lost no time in showing how it could be applied. It was on November 11th that year (still 1912) that he read a paper to the Cambridge Philosophical Society on how the structure of rock salt could be deduced.

As for WH, in Leeds, he enthusiastically embraced the wave theory as a result of WL's insight. The ionisation spectrometer constructed under his direction (in that excellent workshop) was explicitly based on the reflection principle. With that fine instrument as their source of experimental data (far better than Laue photos) WH and WL jointly solved the diamond structure, and WL went on to publish the now-classic series of papers on the alkali halides, ZnS, CaF_2, Calcite, and Pyrite. That was 1912-14. Structural Crystallography had begun.



This inscription is to be found on a plaque on the wall of "Rosehurst", the University of Leeds house in which the Braggs lived during their time in Leeds. It is still used for accommodation for visitors to the University. There are three other Bragg commemorative plaques on the Leeds campus.