The Spectral Line obtained by the Method of Convergent X-Rays

By

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Abstract

The appearance of the X-ray spectral lines obtained with a fine single crystal wire by using the method of convergent X-rays is examined minutely in the present experiment.

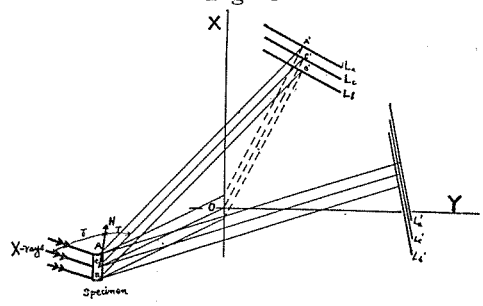
When convergent white X-rays accompanying characteristic radiations of strong intensity strike an atomic plane of a crystal, broad and diffuse Laue-spots will be produced on a photographic plate, and the spectral lines due to the characteristic radiations will also appear[1] in some of the broad Laue-spots. The path of the characteristic radiations producing any such spectral line is the generators of a cone whose vertex is the point on the atomic plane at which the characteristic radiations are reflected, and whose axis is the normal to that atomic plane. The vertical angle of the cone is twice the complement of the glancing angle of the X-rays to the atomic plane.

If a crystal of moderate dimensions is so struck by convergent X-rays that all the atomic planes of the same kind in it are able to reflect the characteristic radiations of the same kind, then a broad spectral line of the characteristic radiations will be produced on the photograph. The appearance of the spectral line thus obtained will be influenced by the distribution of the intensities of the X-rays at various points on the surface of the target.

1. T. Fujiwara: These Memoirs, **11**, 283 (1928)

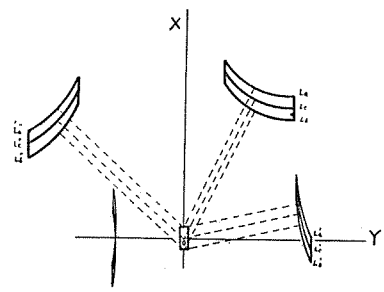
This influence will be more clearly seen when the portion of the specimen illuminated by the X-rays is a thin single crystal wire. In Fig. 1, C is the centre of the slit that is the centre of the specimen ACB, CA the direction of its axis, O the centre of the intense nucleus of the central spot which is produced by the direct beam of X-rays on the photographic plate, and OX and OY are the lines drawn on it respectively parallel and perpendicularly to CA. Three lines provided with two arrows respectively indicate the illuminating characteristic radiations. The line L_c indicates the position of the spectral line of the characteristic radiations, which is caused by the atomic plane of the crystal at the position C, CN is a normal to that atomic plane, and L_a and L_b indicate the positions of the spectral lines which are caused by the same kind of atomic planes of the crystal, situated at the positions A and B respectively. The lines L'_c, L'_a and L'_b indicate the positions of the spectral lines which are caused by different kinds of atomic planes of the crystal, situated at the positions C, A and B respectively.

Fig. 1



Thus every one of the spectral lines has a certain breadth on the photograph, and it is nearly a straight line running perpendicularly to the radial line connecting the centre of the central spot O and that of the spectral line on the photograph. Strictly speaking, however, each line is a little curved, as shown in Fig. 2, and its shape is different according to the position of the spectral line on the photographic plate. In Figs. 1 and 2, all the spectral lines are drawn by taking the size of the diameter of the specimen to be zero.

Fig. 2



These facts are illustrated by the Laue-photographs shown in Figs. 1 and 2 in Plate I, which were taken with single crystal wires of tungsten whose diameters were 0.3 and 0.1 mms. respectively, by

using convergent X-rays radiating from the molybdenum target of a Coolidge tube. In each case the beam of the incident X-rays which was restricted by a conical slit with an opening of 0.5 mm. in diameter, was made to strike the wire perpendicularly to its axis, and also perpendicularly to the photographic plate. The arrow in each figure indicates the direction parallel to that of the axis of the wire.

Generally every one of the Laue-spots appearing on the photograph consists of diffuse weak and strong parts which surround an intense nucleus, and when a spectral line intersects the intense parts the intensity is stronger at the intersection. But in some of the spectral lines in Fig. 1, Plate I, the contrast between the weak and the strong parts is clearer and sharper than would be expected, as shown in Fig. 4 in Plate I, which is an enlargement of the spectral line I in Fig. 1, Plate I. This seems to be due to the presence of such contrast in intensity of the characteristic radiations at the various starting points on the surface of the target; and a further investigation on this point seems not lacking in interest.

Figs. 1 and 3 in Plate I, were taken simultaneously by placing the photographic films parallel to each other at different distances from the specimen. It can be seen from these figures that the distribution of the spots and the spectral lines is, in general, similar in both cases, and that Fig. 1 in Plate I is an enlargement of the other in the ratio of the respective distances between the photographic plate and the specimen. Though in each spectral line, its distance from the other spectral lines, its length and the distance between two strong striae in it are enlarged in the photograph taken at a greater distance in the ratio of the respective distances of the photographic plates from the specimen, its width is nearly the same in both photographs. Figs. 1 and 2 in Plate II are respectively the enlarged photographs of some spectral lines in Figs. 1 and 3 in Plate I. An interesting spectral line consisting of several lines arranged nearly parallel is found in Figs. 1 and 3 in Plate I, and is shown more clearly in Fig. 3 in Plate II, which is an enlarged photograph of the spectral line II in Fig. 1, Plate I. By examining this line closely in Figs. 1 and 3 in Plate I, it is found that the presence of such a fine structure in it is due to the reflection of the X-rays from the parallel atomic planes in different thin sheets of crystal layers arranged nearly parallel at certain small intervals.

In conclusion, the writer wishes to express his sincere thanks to Prof. U. Yoshida, of Kyoto Imperial University for his invaluable suggestions.

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Plate I

Fig. 1

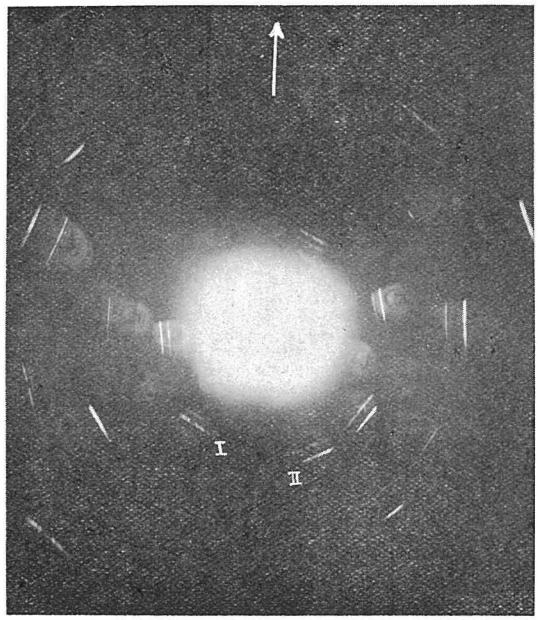

Fig. 2

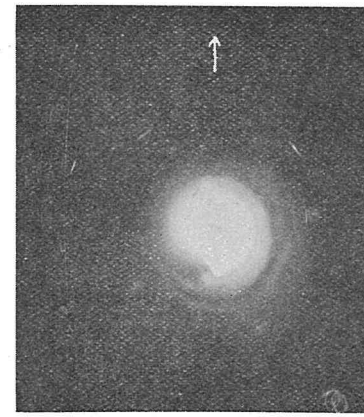

Fig. 3

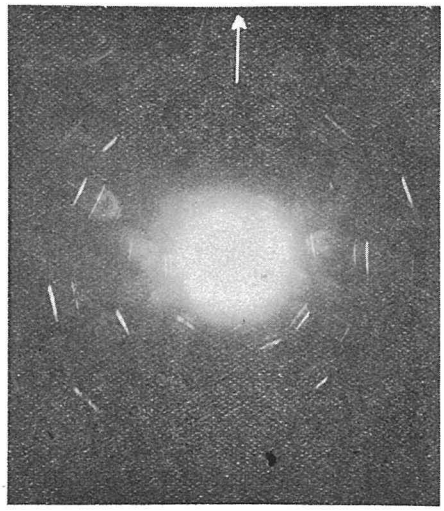

Fig. 4

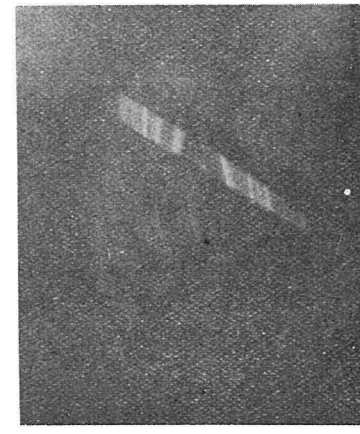

Plate II

Fig. 1

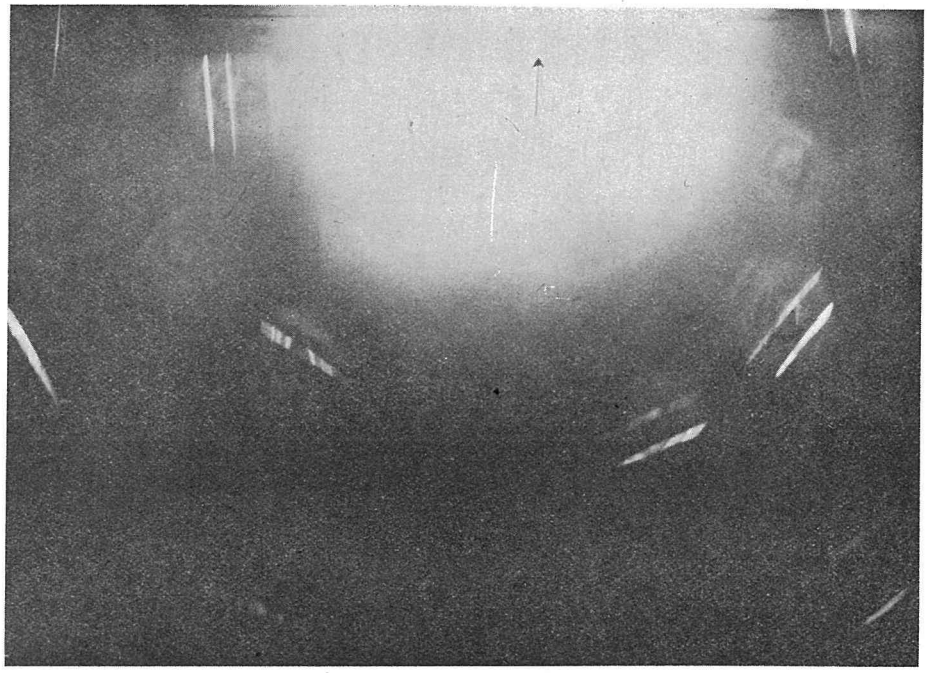

Fig. 2

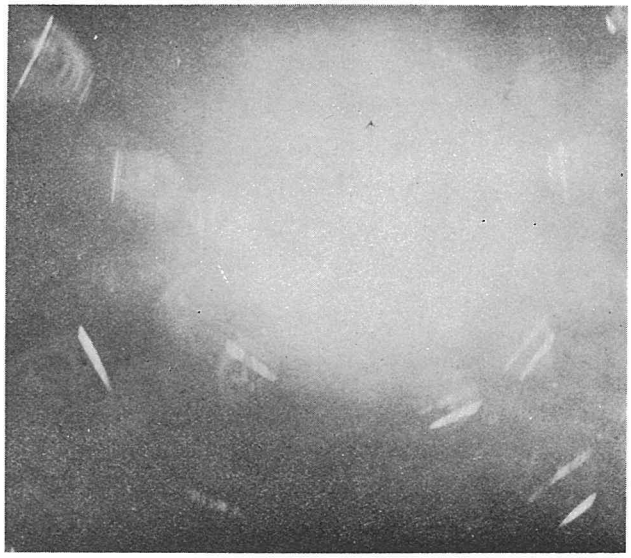

Fig. 3