Letters to the Editor.

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Diffraction of X-rays by Two-Dimensional Crystal Lattice.

UNDER this title, W. Linnik, of the Leningrad Optical Institute, described in a recent issue of NATURE (April 20) an effect obtained with copper $K\alpha$ radiation and a mica crystal. A narrow beam of X-rays was passed through a cleavage plate of mica, which had previously been heated to redness and cooled. A photograph of the diffracted beam showed a series of spots, the arrangement of which is attributed by Linnik to the action of very thin layers of the crystal as independent two-dimensional gratings. It is supposed that "the space effect will be destroyed by the incoherence of waves produced by scattering from incorrectly spaced layers", the heat treatment having broken up the mica into very thin plates without disturbing their orientation. The arrangement of the diffracted beams corresponds to the pseudo-hexagonal network of points at intervals of 5.2 Å. in the cleavage plane (001), which is so striking a feature of the mica structure.

I do not think it is necessary to postulate diffraction by a two-dimensional lattice in order to explain Linnik's results; they can be ascribed on the other hand to diffraction of the familiar type by the three-dimensional crystal grating, provided that one may assume the mica to consist of a number of flakes not quite parallel to each other. The normals to these flakes have a random orientation about a certain mean position, though the flakes themselves retain their relative position in the sense that there is no rotation of one flake over another around the mean normal.

To test whether such a structure of the mica plate would produce the effect observed by Linnik, the following experiment was tried by Mr. W. H. Taylor and myself. A cleaved section of muscovite mica, 0.6 mm. in thickness, was set up approximately normal to a narrow beam of molybdenum K radiation. During the exposure of a photographic plate, the section was rotated over a small range around both horizontal and vertical axes normal to the X-ray beam. The effect of this double rotation is to make the normal assume in turn all positions within a small solid angle extending five degrees in every direction from its mean position. The resulting photograph (Fig. 1), while showing more spots owing to the shorter wavelength, has precisely the same appearance as that published by Linnik. There is a complete and fairly uniform series of spots such as would be made by a two-dimensional grating, though in this case the crystal was quite normal and there is no reason to ascribe the effects to anything but the familiar three-dimensional diffraction. When kept stationary the crystal gave a Laue pattern; when heated this was partly replaced by the pattern of Fig. 1, though we did not succeed in obtaining so symmetrical a pattern with the heated crystal as that obtained by Linnik.

This simulation of a two-dimensional grating effect can be readily understood if the mechanism of diffraction is considered. Two of the three conditions for the diffraction of a monochromatic beam are imposed by the spacing of the points on the basal net (the cleavage plane (001)). Thus any diffracted beams

which appear must have such positions as are to be expected from this two-dimensional grating. It can readily be calculated that the slight rocking to and fro of the mica does not appreciably affect these positions, a result familiar in the optical grating when the angle of diffraction is small. The third condition for diffraction is achieved by the oscillation of the crystal. Owing to the great length of the c axis (20 Å.) a very slight rocking of the crystal (or warping of its surface) will suffice to bring points in successive c planes into such a relative position that reinforcement takes place.

To put this more precisely, when a point on the plate is formed by reflection from the plane (hkl), its

FIG. 1.

position only depends on h and k , being independent of l if second-order corrections are neglected. A rocking of $6\frac{1}{2}^\circ$ in every direction ensures that, for every value of h and k , some plane hkl comes into position for reflection. If h and k are large, many values of l are possible, and the corresponding spot is due to the superposition of several diffracted beams.

It is interesting to follow the changes to be expected as the wave-length is shortened. The spots will crowd towards the centre and form a more and more regular triangular pattern. Each outer spot is formed by the co-operation of a number of planes differing in index l ; hence an average between weakly and strongly reflecting planes is struck and the outer spots will be regular in intensity. The photograph will in fact repeat all the features shown in the results of Kikuchi (*Japanese Journal of Physics*, 5, 2; 1928) on the diffraction of electrons by mica, quoted by Linnik. Its appearance can be readily explained by the familiar laws of diffraction by a three-dimensional grating, assuming a slight random warping of the mica planes. It is not necessary either in the case of electron diffraction or X-ray diffraction to assume that the crystal acts as a two-dimensional grating.

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Asymmetry in the Radiation from the Hydrogen Atom in the Electric Field.

IN my monograph "Axialität der Lichtemission und Atomstruktur" (Polytechnische Buchhandlung A. Seydel, Berlin, 1927) I have discussed a case of asymmetry of radiation; if atoms of an element, say of helium, pass through a gas such as hydrogen, under certain conditions for some spectral lines of the moving atoms the radiation in the direction opposite