LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twenty-eighth of the preceding month; for the second issue, the thirteenth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Laue Spots From Perfect, Imperfect, and Oscillating Crystals

G. W. Fox and P. H. Carr[1] have made the interesting observation that oscillating piezoelectric quartz crystals produce Laue patterns several times more intense than nonoscillating crystals. It occurred to me soon after seeing their abstract that an explanation of the effect might lie in the distortions of the lattice caused by the oscillations. These lattice distortions should produce a state of imperfection in the lattice with a consequent reduction in extinction and an increase in reflecting power for x-rays.

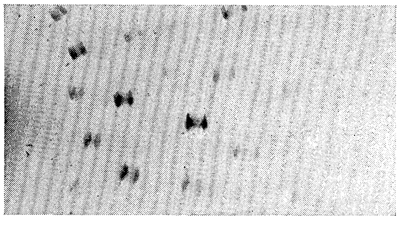

Fig. 1. Laue spots from nonoscillating quartz.

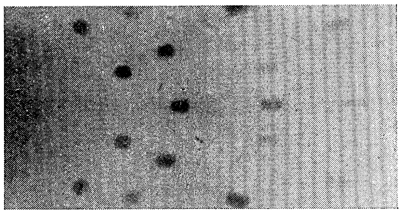

Fig. 2. Laue spots from rock salt.

A convenient method of testing this idea was suggested by Laue photographs I had taken in 1928 and 1929 of some crystals 0.7 to 2.0 mm thick whose surfaces had been ground with emery paper. These were taken with rays from a molybdenum tube at 30,000 volts collimated by a slit with a square cross-section 0.02″×0.02″ and 2-3/16″ in length, the ground surfaces of the crystal and the photographic plate, separated by 4 cm, were both placed perpendicular to the beam. Fig. 1 is an enlargement of some of the spots of the pattern obtained from a nonoscillating quartz crystal with this arrangement. The spots are elongated radially, their radial length, l, being related to the thickness, t, of the crystal by the simple relation $l = tr/d$ where r is the distance from the central spot on the plate to the Laue spot in question, and d is the distance from crystal to plate. Since the reflected rays forming a spot are very nearly parallel, the inner ends of the spots are formed by rays from the surface of the crystal nearer the plate, the outer ends by rays from the remote surface of the crystal, and intermediate parts of the spots from corresponding portions of the interior of the crystal. Each spot gives therefore an indication of the reflecting power at the different points in the crystal irradiated by the primary beam. The doublet character of the spots in Fig. 1 is due to the intense reflection from the surfaces which had been rendered imperfect by grinding, a process evidently not affecting the more perfect interior of the crystal. It was expected that rock-salt crystals, long famous for their imperfection, would yield Laue spots of uniform blackening throughout. Such was found to be the case; there was practically no added reflecting power at the ground surfaces, as is seen in Fig. 2. It was subsequently found that Y. Sakisaka[2] had studied this phenomenon in detail in quartz concluding that grinding disturbed the perfection in quartz to a depth of

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[1] Fox and Carr, Phys. Rev. **37**, 1695(A), 1622 (1931).

[2] Sakisaka, Jap. Jour. Phys. **4**, 171 (1928).

about 0.1 mm, and that the increased reflecting power of the ground portion was due to a reduction in primary extinction.

Returning now to the case of oscillating crystals, a more convenient test for oscillating imperfection in them could scarcely be asked for. Accordingly Dr. Carl E. Howe and myself have taken a number of Laue photographs of oscillating crystals under the conditions described above. Fig. 3 is an enlargement of some of the spots from an oscillating X-cut crystal 2.78 mm thick photographed July 16, 1931. As will be seen, the crystal produced Laue spots of nearly uniform blackening even though its surfaces were ground, indicating that the interior of the crystal has a reflecting power approximating that of the ground surfaces. On five photographs of nonoscillating crystals (both 0° and 30° cuts) with ground surfaces every spot was a doublet resembling those of Fig. 1, while on the several plates taken with oscillating crystals almost none of the spots were of this type. It seems certain that the explanation in the first paragraph is correct, and that these results and those of Fox and Carr are thus to be explained.

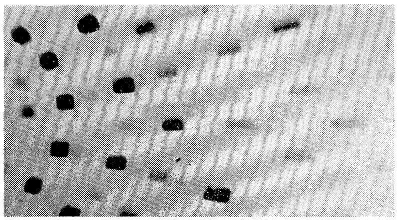

Fig. 3. Laue spots from oscillating quartz.

B. E. Warren and also R. M. Langer have proposed explanations in these columns for Fox and Carr's observation. Warren's suggestion, that the characteristic wave-lengths from the target are involved, can hardly be applicable since on our photographs a great number of different wave-lengths produce spots which show the effect. On the other hand these results are in agreement with the general principles of Langer's suggestion. The information available at present, however, is scarcely sufficient to test his notion that the crystal is composed of small blocks which tilt from their rest positions during oscillations without destroying their perfection. An alternative explanation that must also be considered is that the perfection is reduced by a warping of the lattice during oscillations.[3]

Further work on the subject is in progress at this Laboratory.

CHARLES S. BARRETT
Naval Research Laboratory,
Bellevue, Anacostia, D.C.

July 27, 1931.

[3] Cf. C. G. Darwin, Phil. Mag. **43,** 800 (1922).

The Magnetic Anisotropy of Ions of the Type XO_3

In connection with the letters published recently in The Physical Review from W. H. Zachariasen and Maurice L. Huggins on the structure of ions of the type XO_3, the results of some magnetic measurements on these ions made by the present writer with Mr. B. C. Guha, may be of interest.

Among a large number of crystals measured by us for their magnetic anisotropy, are included some carbonates, viz., calcite, aragonite and strontionite, sodium and potassium nitrates and potassium chlorate, all of which are diamagnetic. Of these, calcite and sodium nitrate being trigonal crystals, have naturally an axis of both optical and magnetic symmetry. The other crystals are optically biaxial, but two of their principal refractive indices are so nearly equal that for practical purposes they may also be treated as uniaxial. Magnetically also it is found that they have an axis of similar pseudo-symmetry, the approximation to actual symmetry being even closer than in the optical case. The optical and magnetic symmetry axes are coincident. Table I gives for each crystal the difference between its principal susceptibilities, as also the difference between its principal refractivities—i.e., the magnetic and optical anisotropies of the crystal. $\chi_\parallel$ and $\chi_\perp$ in the table denote the values of the susceptibilities per gram molecule, along and perpendicular to the axis of symmetry respectively: R_e and R_0 denote similarly the gram molecular refractivities for the D-line, (defined as usual by $[(n^2-1)/(n^2+1)]M/\rho$), for vibrations along and perpendicular to the axis respectively.

Since the metallic ions in these crystals are presumably isotropic, and x-ray evidence suggests that the negative ions in them are oriented parallel to one another, the values given in the table for the magnetic and optical anisotropies of a crystal may be taken to

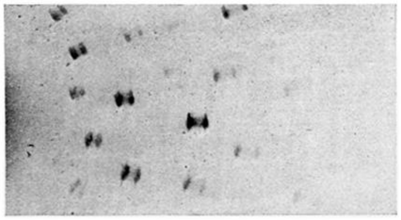

Fig. 1. Laue spots from nonoscillating quartz.

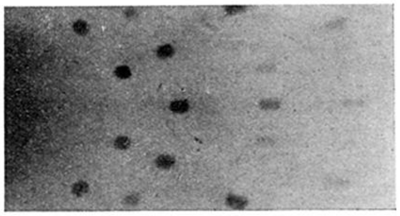

Fig. 2. Laue spots from rock salt.

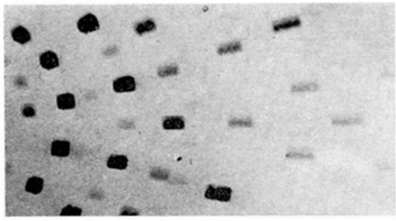

Fig. 3. Laue spots from oscillating quartz.