Experimental observation of diffraction focusing of a spherical x-ray wave

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We have observed experimentally a new effect—focusing of a spherical x-ray wave via two-wave diffraction in perfect crystals.

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A dynamic theory of diffraction of a spherical x-ray wave in perfect crystals, with account taken of the distance from the source to the detector, was developed in Ref. 1, and a new effect was predicted, namely diffraction focusing of a spherical x-ray wave. This theory is of interest also because it is possible on its basis, as noted in Ref. 2, to understand those experimentally observed[3] singularities of many-wave diffraction, which cannot be explained by the dynamic theory of diffraction of a plane wave.

It is clear that the primary task here is to observe in experiment the focusing effect predicted in Ref. 1. We have performed the experiment in unpolarized CuK_β radiation from a BSM-1 x-ray tube. A wedge-shaped sample of dislocation-free germa-

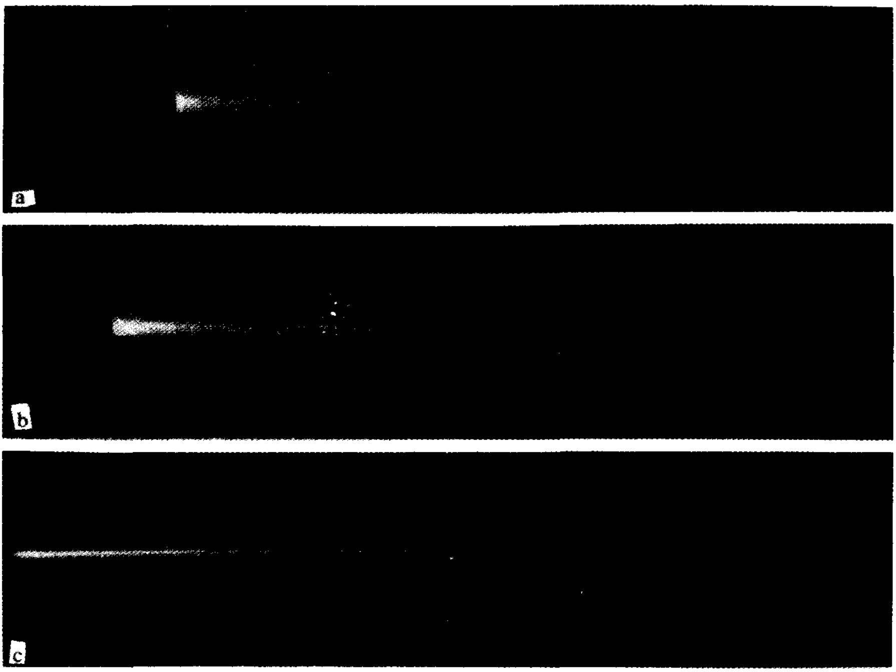

FIG. 1. Two-wave reflection (220) from a perfect wedge-shaped Ge sample; CuK_β radiation. Distance between the source and the sample 108 cm. Magnification 10×: a) sample—detector distance $L = 6$ cm; exposure $T = 40$ h; b) $L = 54$ cm, $T = 48$ h; c) $L = 108$ cm, $T = 42$ h.

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nium was located at a distance 108 cm from the source, and the detector (photographic film "Mikrat-300") was located at distances $L = 6$, 54, and 108 cm from the sample. Symmetrical two-wave (220) Laue diffraction was realized. Photographs of the x-ray patterns of the diffracted beam are shown in Fig. 1.

At small L (Fig. a) the beam broadens greatly in the region of the pendulum bands, i.e., at crystal thicknesses $t < 100\ \mu\text{m}$. With increasing L, this broadening becomes less noticable, as do also the pendulum bands (Figs. b and c). No focusing is observed in Figs. a and b, this being due to the nonmonochromaticity of the radiation incident on the crystal. When the sample–detector distance becomes equal to the source–sample distances, the maximum of the reflections of all the wavelengths coincide and the focusing is clearly pronounced (Fig. c). The reflection in the central part takes in this case the form of a sharply outlined nucleus surrounded by a weak background. With decreasing t, the intensities of the nucleus and of the background become practically the same; when t is increased the background vanishes and the nucleus of the reflection broadens noticeably.

It should be noted that the beam is focused by a sufficiently wide range of crystal thicknesses, $50\ \mu\text{m} \leqslant t \leqslant 300\ \mu\text{m}$. The crystal focusing thickness predicted in Ref. 1 lies in this region.

It can thus be concluded that the theory developed in Ref. 1 has been experimentally confirmed. The next step is to use it to explain many-wave effects.

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