A MODEL FOR BIAXIAL CRYSTALS

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Most students have difficulty in visualizing the optical relations in biaxial crystals and the instructor finds it helpful to use models of some kind to supplement the diagrams given in the textbooks. Various models of the wave-surfaces, Fresnel ellipsoids, and index ellipsoids have been made and may be procured from German dealers. In my course in crystal optics I employ the index ellipsoid exclusively, following the suggestion of F. E. Wright.[1] A model of

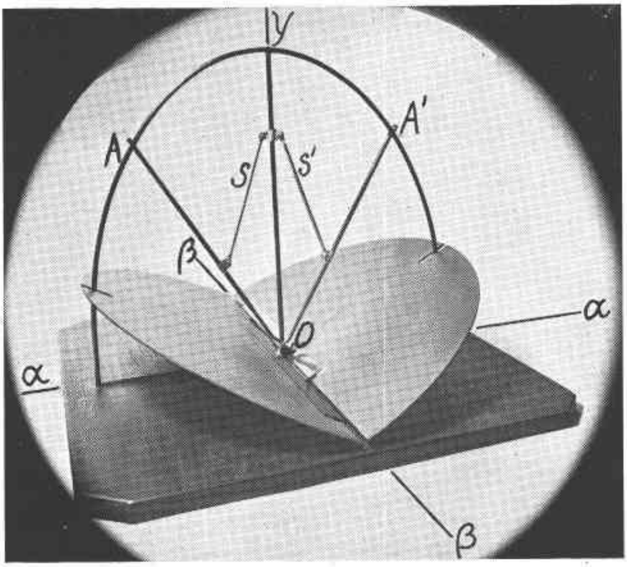

Fig. 1. Model to illustrate the optical properties of biaxial crystals. It is essentially half the index ellipsoid of a positive crystal in which the axial angle AOA' may be varied from 7 or 8° up to nearly 90°. (About one-sixth natural size.)

a triaxial ellipsoid is almost indispensable but it is hardly adequate to elucidate all of the important optical features of biaxial crystals.

I have found the model illustrated in the accompanying photograph very useful in class work. It is a model of one-half of the index ellipsoid. While none of the actual surface of the ellipsoid is present, all of the important optical directions are represented.

[1] *Am. Jour. Sci.* [4], vol. **35**, pp. 133–138, 1913.

The model is constructed upon a polished wooden base about 36 cm. square and 13 mm. thick. The half-ellipse in a vertical position represents the optic axial plane. The vertical standard, a brass rod of 4 mm. diameter, is γ and the major semi-axis of the ellipse corresponding to n_γ is 24 cm. long. The direction approximately horizontal in the photograph and at a right angle to γ in the model is α. The length of the minor semi-axis of the ellipse corresponding to n_α is 15 cm. The optic normal at right angles (in the model) to both γ and α is β and the intermediate semi-axis n_β is $17\frac{1}{2}$ cm. long.[2] The semi-circular discs with radii equal to n_β ($17\frac{1}{2}$ cm.) are halves of the circular sections of the ellipsoid. These discs are made from black sheet bakelite 2 mm. thick. They fit into metal hinges which move about β; the other parts of the hinges are attached to the wooden base. The rods *AO* and *A'O* represent the optic axes. The outer portions of the optic axes are hollow rods into which the inner solid rods fit, and along which they slide. The inner solid rods are permanently attached to the centers of the semi-circular discs and in a position normal to the discs.

The optic axes and the semi-circular discs move simultaneously and this is brought about by the aluminum rods *s* and *s'*, the lower ends of which are permanently fixed to the hollow portions of the optic axes. The upper ends of the rods *s* and *s'* are attached to a kind of hollow toggle-joint which slides up and down on γ. It is to be regretted that the rods *s* and *s'*, which do not in any way represent optical directions, have to be present, but it is essential that the axial angle shall always be bisected by γ. The model was at first constructed without these rods and the aspect of the model often with a small V on one side of γ and a large V on the other side was most disconcerting.

The angle 2V between the optic axes may be varied from 7 or 8° up to nearly 90°. The semi-ellipse is notched at intervals of 10° so that the approximate value of 2V may be read off. The semi-circular discs have slits $2\frac{1}{2}$ cm. long in the direction of the optic axial plane; this is necessary in order that 2V may be made as small as possible. The radius of the circular sections should of course vary with the size of the axial angle but this seems hardly practicable in a model of this kind. In the present model the circular

[2] I use α, β, and γ for directions and n_α, n_β, and n_γ as indices of refraction for the corresponding directions.

sections have the correct radius for a value of 2V of about 75°.

The model illustrated is for optically positive crystals, since the value of n_β is closer to n_α than to n_γ. A model for optically negative crystals could be constructed by making n_β closer to n_γ than to n_α. In this case it would be necessary to have α in a vertical position since in negative crystals it is the acute bisectrix.

A possible improvement in the model could be made by adding a semi-ellipse $\gamma\beta$ and an ellipse $\beta\alpha$ made of brass rods bent to shape. The model then would doubtless look more like the index ellipsoid, but the optic axial plane would be less prominent. The semi-circular discs can be easily removed. Therefore it would be feasible to have a number of interchangeable discs with radii of different lengths, but this would seem to be an unnecessary refinement.

The model described in this article was constructed by Mr. Frank D. Banham, chief mechanician at Stanford University.