NOTES AND NEWS

LABORATORY DEMONSTRATION OF THE NATURE OF INTERFERENCE COLORS PRODUCED BY A QUARTZ WEDGE BETWEEN POLAROIDS*

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In the laboratory the nature of the interference colors produced by the quartz wedge between polaroids may be easily demonstrated. The value of the demonstration has been established by repeated use in teaching elementary crystal optics.

An ordinary quartz wedge, such as is used with a polarizing microscope, is mounted over a slit which is parallel to the length of the wedge. The slit is of the same length as the wedge, and may be about 1 mm. wide. The wedge is placed between a pair of polaroids, at least one of which is arranged to rotate in the usual manner. The vibration direction of the polarizer is set at 45° to the vibration directions of the wedge. An arc lamp is placed behind the slit, wedge, and polarizer, and a lens, whose diameter is slightly greater than the length of the slit, is placed close to the slit on the side of the arc lamp. The arc is placed conjugate to the lens of a long bellows extension plate camera. This method of illumination produces a very even and fairly intense illumination of the slit and quartz wedge. The camera is mounted so that an image of the slit may

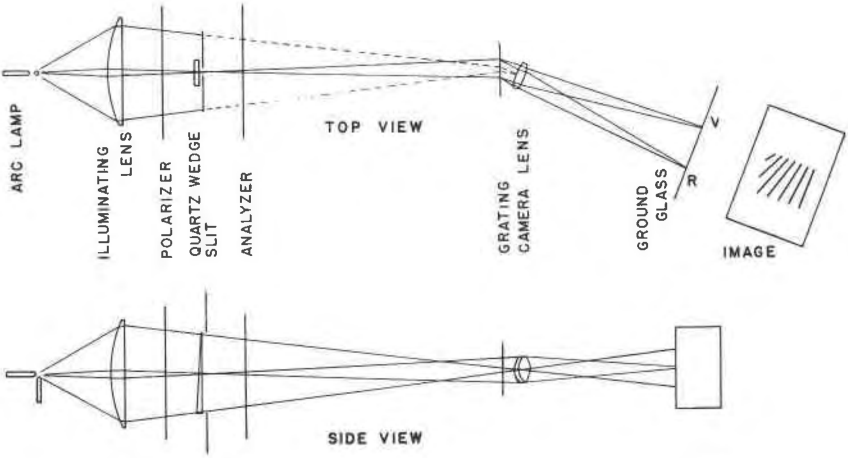

Fig. 1. Schematic demonstration of the spectral composition of quartz wedge interference colors.

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* Contribution from the Department of Mineralogy and Petrography, University of Michigan, No. 192.

be focused on the ground glass of the camera. A transmission replica grating, crossed with respect to the quartz wedge, is placed before the camera lens. The camera is fixed so that a first order spectrum is focused on the ground glass. The above arrangement is satisfactory for demonstration to small groups of students. The arrangement of apparatus is shown in Fig. 1.

The interference pattern exhibited by the wedge between crossed (Fig. 2) and parallel (Fig. 3) polaroids is readily appreciated by the beginning student. For crossed polaroids the dark bands represent a retardation of $n\lambda$ and each light band represents a retardation of $(2n+1)/2\ \lambda$. Of course, for parallel polaroids the reverse is true.

Since the retardation introduced by the crystal plate is proportional to the thickness of the plate, and the wedge has a uniform taper, the retardation scale parallel to the slit is linear. As quartz possesses very little dispersion of birefringence, the retardation scale is valid, for all ordinary purposes, for all wavelengths. The grating used as indicated above gives a practically linear dispersion at right angles to the slit. Consequently, the light and dark bands are portions of straight lines passing through the origin, if the small dispersion of birefringence is neglected.

The spectral nature of any intereference color within the limits of the wedge can be seen at a glance. Upon rotation of one of the polaroids from the crossed position, the intensities of the light and dark bands change until at 45° an evenly lighted spectrum is seen, since only one of the vibration components transmitted by the quartz reaches the analyzer. As this 45° position is passed, dark bands reappear in the position previously occupied by the light bands.

An informative exercise for the student is the graphical construction of a retardation scale on a print similar to that shown in Fig. 2. The actual photograph is made with an ordinary desk type fluorescent lamp placed behind the polarizer, without the illuminating lens. When the photographs are taken in this manner, an essentially continuous spectrum, punctuated by the strong mercury lines, is produced. The mercury lines provide wavelength markers in the spectrum. The construction is most easily carried out by interpolating on the linear wave length scale to 500 mμ and drawing a vertical line on the print corresponding to this wave length. Then the intersection of the dark bands with this line are projected horizontally to the retardation scale. Thus the retardation scale is marked in convenient 500 $m\mu$ units.

The slight displacements of the bright spectral lines where the latter cross the dark interference bands are due to the use of an unusually long slit and the absence of a collimating lens before the grating. Their presence, which could be avoided by the use of a suitable collimator, does not detract appreciably from the value of the exercise.

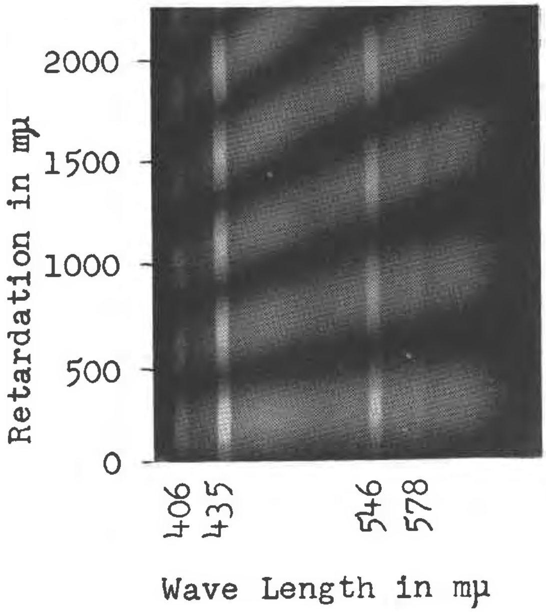

FIG. 2. Dispersed image of quartz wedge between crossed polaroids.

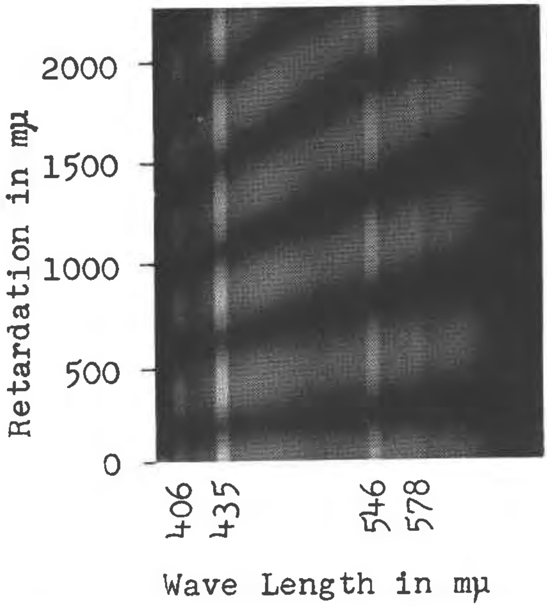

FIG. 3. Dispersed image of quartz wedge between parallel polaroids.

Incidentally the principle of calibrating retardation devices with the aid of a spectrometer is also illustrated.

An instructive variation of the experiment is to arrange both polaroids to rotate synchronously, which demonstrates that, as a crystal is brought from a position of maximum illumination to extinction, the amplitudes of the light waves passed by the analyzer vary, but the phase relations remain unchanged.

An interesting modification for advanced students of crystal optics would be to substitute for the quartz wedge a wedge of a substance showing strongly "anomalous" interference colors. If a substance exhibiting considerable dispersion of birefringence were substituted for the quartz, the interference bands would not be segments of straight lines passing through the extrapolated zero wavelength. In this case the retardation scale would be different for each wavelength. Even in the case of the quartz wedge the bands do not intersect at the origin; actually they intersect on the positive side of the wavelength zero. The displacement is of the order of 50 $m\mu$ which is in agreement, within the large experimental error, with published data on the indices of quartz.[1]

Photographs essentially similar to Figs. 2 and 3 were published by Hauswaldt.[2]

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[1] Handbook of Chemistry and Physics, edited by Charles D. Hodgman and Harry N. Holmes, Chemical Rubber Publishing Company, Cleveland, Ohio, 1941, p. 2103.

[2] Hauswaldt, Hans, Interferenzerscheinung im Polarisirten Licht, Neue Folge, 1904, Plates 26, 27, 28.

THE PRIMITIVE CELL OF JOHANNITE

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The pseudo-monoclinic cell of johannite $Cu(UO_2)_2(SO_4)_2(OH)_2 \cdot 6H_2O$ (Peacock, 1935), with morphological axial elements

$$a:b:c=0.9182:1:0.3799,$$
$$\alpha=90°54\tfrac{1}{2}', \quad \beta=90°38', \quad \gamma=110°37',$$

is all-face-centered (F). The cell obtained from it by transformation $\frac{1}{2}0\frac{\bar{1}}{2}/0\frac{\bar{1}}{2}\frac{\bar{1}}{2}/001$ (Hurlbut, 1950; quoted by Palache, Berman, and Frondel, 1951) is primitive (P) but unconventional in that it is referred to a left-handed system of coordinates.[1]

The conventional P cell is obtained from the F cell by transformation $\frac{\bar{1}}{2}0\frac{\bar{1}}{2}/0\frac{\bar{1}}{2}\frac{\bar{1}}{2}/001$. The axial elements, calculated from Peacock's numerical values, are

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[1] The figure given by Hurlbut (1950, p. 533) should be relabelled as follows. Instead of c_0 read $-c_0$ and instead of c_0' read $-c_0'$. For each cell the origin is to be taken at the lattice node where the three labelled edges meet.