METHOD OF DETERMINING THE CORRECTION TO BE APPLIED
WHEN MEASURING THE ANGLE OF ROTATION
OF THE PLANE OF POLARIZATION

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When the angle of rotation of the plane of polarization is being measured in a photoelectric spectropolarimeter, the existence of a certain spectral distribution of the radiation incident on the polarizer gives rise to a systematic error; the extent of this error depends on the rotatory dispersion of the substance under examination and also on the spectral distribution of the photocurrent. The existence of this error means that, if one measures the rotatory power of the same substance in different spectropolarimeters, one will obtain different values of the angle of rotation of the plane of polarization for a particular wave-length in the middle of the spectral range of the monochromator slits.

When measuring the rotation of the plane of polarization of substances for which the rotatory dispersion in the particular spectral range obeys a one-term Drude equation

\[ \alpha = \frac{a}{\lambda^2 - b}, \]  

where \( \alpha \) is the angle of rotation of the plane of polarization, \( \lambda \) is the wavelength of the light, \( a \) and \( b \) are coefficients of the equation; this error may be expressed [1, 2] by the formula

\[ \Delta = \left( \frac{da}{d\lambda} \right)_{\lambda = \lambda_{av}} \left( 0.1667c - \frac{1.1b + 0.7485\lambda_{av}^2}{\lambda_{av}^3} \right) (\Delta \lambda)^2, \]  

where \( \Delta \) is the measuring error ..., \( \Delta \lambda \) is the spectral range of the monochromator slit, \( \mu \); \( \lambda_{av} \) is the wavelength of the light in the center of the spectral range; \( \left( \frac{da}{d\lambda} \right)_{\lambda = \lambda_{av}} \) is the derivative of the rotatory dispersion of the sample; \( c \) is the slope (tangent) of the curve representing the relative distribution of photocurrent \( I_\lambda / I_{\lambda_{av}} \) at a point corresponding to \( \lambda_{av} \).

Formula (2) was derived on the basis of a triangular apparatus function of the monochromator and a linear function \( I_\lambda / I_{\lambda_{av}} \) within the spectral range in question.

The angle of rotation of the plane of polarization for a particular wavelength in the center of the spectral range may be obtained by introducing a correction to the measured value in accordance with the formula

\[ \alpha = \alpha_{\text{meas}} - \Delta. \]

The effect of the monochromator slit width on the results of measurements made on the rotation of the plane of polarization was studied on a spectropolarimeter constructed in the Optical-Measurements Laboratory of the All-Union Scientific-Research Institute of Crystallography in an attempt to prove formula (2) and develop methods of determining the correction experimentally.

The arrangement of a spectropolarimeter using the method of the penumbral angle is shown in Fig. 1. The light from the source 1 passes through the monochromator 2, the exit slit of which lies in the focal plane of the lens 3, and falls on the polarizer 4. Then the plane-polarized light passes through the lens system 5 into the modulator 6, the operation of which is based on the Faraday effect. The modulator is a core of TF-5 glass placed in an alternating magnetic field created by a solenoid. The solenoid is fed with ac at a frequency of 50 cps from the mains supply. In order to increase the amplitude of the penumbral angle the core is made so as to be traversed...
The polarizer and analyzer are Thompson-Glen prisms. The analyzer, rotating on a conical axis, is connected to the circular scale 9, which is read with optical microscope (1" scale divisions). The sample to be measured is placed between the modulator and analyzer. The special cuvette holder is furnished with a TL-19 thermometer (scale division 0.1\(^\circ\)).

If the crossed position is not held, a 50 cps ac signal arises in the system and rotates the electric motor. With the analyzer and polarizer in the crossed position, a retarding 100-cps signal develops in the system. The speed of the system is 40\(^\circ\) in 15 sec.

The final result of the measurement equals the difference between two readings on the graduated circle. The first reading is taken after the motor stops with the sample in position and the second in the absence of the sample.

As a suitable sample for measurement we chose quartz, the rotatory dispersion of which has been thoroughly studied by Lowry [3]. We measured the angle of rotation of the plane of polarization of a quartz plate 1.594 mm thick (already standardized for the sodium doublet \(\lambda = 0.58925 \mu\) to an accuracy of \(\pm 0.0028\)\(^\circ\)) for various slit widths and four wavelengths: 0.6438, 0.5896, 0.5086 and 0.4678\(^\mu\). The angles of rotation of the plane of polarization of the quartz plate for these wavelengths were calculated from Lowry's data, which gave the specific rotation of quartz for the spectral lines to the fourth decimal place.

The light source was a 24-V glow lamp (340 W) fed with dc from a storage battery.

Before measurement, the drum of the monochromator was set at the required wavelength by reference to a low-pressure spectral lamp. During the measurements the multiplier was fed with a voltage of 1100 V, so that the level of the intrinsic noise in the electronic circuit was below the threshold of sensitivity of the system, i.e., in the absence of a light flux the motor remained stationary. The signal at the amplifier output was checked with a voltmeter and kept constant. The increase in the signal on the photomultiplier due to increasing the slit width of the monochromator was compensated by reducing the amplification factor of the amplifier. The penumbral angle was 8\(^\circ\), and this remained unaltered during measurement. The mean-square error of the measurement was \(\sigma = 0.0014\)\(^\circ\).

We determined the angle of rotation of the plane of polarization as a function of the monochromator slit width. The widths of the entrance and exit slits were kept the same. Since the light flux was proportional to the square of the monochromator slit width, we were unable to vary the slit widths over a very wide range; hence the determination of each relationship was restricted to six points only.

The final result of the measurements was taken as the arithmetic mean of nine measurements of the rotation of the plane of polarization for the particular slit width in question. For each of the nine measurements we introduced a temperature correction. The limiting random error of the arithmetic mean of the nine measurements was \(\pm 0.0018\)\(^\circ\).

### Table 1

<table>
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<tr>
<th>(\lambda_{av})</th>
<th>(\alpha^*)</th>
<th>(\gamma/\mu)</th>
<th>(\alpha^* , \mu^2)</th>
<th>(\alpha_{av}^* , ... , \circ)</th>
<th>(\frac{d\alpha}{dt})</th>
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