DETERMINATION OF THE CHARACTERISTICS OF INTERFERENCE FILTERS WITH A SPECTRAL INTERFEROMETER

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Interference filters are used in very dissimilar fields of science and technology. They can provide highly monochromatic radiation (the average transmission band of a filter is of the order of 5 nm) and are, therefore, suitably used in place of monochromators in various cases. The highly accurate determination of the characteristics of interference filters is one of the important tasks of interferometry.

The principal parameters of a light filter are [1, 2]:

- **Width of the transmission band**
  \[ \delta \lambda = \frac{\lambda}{k \cdot N_e} \]  
  where \( k \) denotes the interference order, with \( k = \frac{2 \pi}{\lambda} \) (\( t \) is the thickness of the transparent layer between the mirror layers of the filter and \( n \) denotes the refractive index of a particular layer); \( N_e \) denotes the number of interfering light beams of equal intensity, with \( N_e = \pi \sqrt{2} \tau / (1 - \tau R) \) (\( \tau \) denotes the absorption coefficient of the transparent layer, and \( R \) is the reflection coefficient of the mirror layers). Equation (1) is valid for \( \varphi = 0 \) and \( (\lambda / \pi) (\partial \delta / \partial \lambda) \ll k \), where \( \varphi \) denotes the angle of light incidence on the filter, and \( \delta \) denotes the phase change at the reflecting surfaces.

- **Wavelength of the transmission-band maximum**
  \[ \lambda_{\text{max}} = \frac{2\pi n}{k - \delta / \pi} \]  
  at \( \varphi = 0 \). In order to determine small shifts of the transmission-band maximum when a nonparallel light beam is incident on the filter, the expression of [3] is used:

\[ d \lambda = 0.25 \cdot \psi \cdot \lambda_{\text{max}}. \]  

- **Contrast factor**
  \[ C = \frac{I_{\text{max}}}{I_{\text{min}}} = \left( \frac{1 \pm \tau R}{1 - \tau R} \right)^2 \]  

- **Filter aperture** \( \psi \) which is defined as the maximum opening angle of the light cone for which a noticeable deterioration of the monochromatic filter effect due to angular divergence of the incident beam is not yet observed; the filter aperture is given by the formula

\[ \psi = 2\pi \sqrt{\frac{d \lambda}{\lambda_{\text{max}}}}. \]  

These equations allow a theoretical calculation of the parameter characterizing single-reflection interference filters. In practice, however, the position of the transmission band maximum can be obtained with an error of several manometers relative to the calculated values and actual filter performance figures are necessary. These checks are particularly important in the case of filters used in interferometers in which one must know the maximum of the transmission band with an accuracy of not worse than 0.5 nm.

One can use a photoelectric Fabry-Perot spectro-interferometer for experimental checks of this kind. In spectro-interferometers of the vertical design form [4], the filter under investigation must be introduced into the Fabry-Perot interferometer on a quartz plate which is placed in the parallel beam and serves as a support. When an autocollimating instrument is used, the filter plane is set exactly perpendicular to the incident light beam.

Four filters with transmission bands in the visible region of the spectrum were investigated. A diffraction grating with 1200 lines/mm was used as the dispersion system in the interferometer. The instrument was provided with a mechanical drive mechanism which could produce three rotation rates of the diffraction grating, i.e., three scanning rates of the spectrum (0.282, 0.105, and 0.053 nm/sec). The average rate $v = 0.105$ nm/sec was used for work with the light filters. An incandescent lamp was used as the source of white light, and an FÉU-51 photomultiplier served as the light receiver.

Recordings of the transmission bands with scale marks indicating the angle of grating rotation were made (Fig. 1). In order to eliminate a possible slack motion of the rotation mechanism for the grating, the recording of the transmission band was made twice in different scanning directions.

The transmission-band maximum was graphically determined on the recording and expressed by scale divisions. In addition, the half-width of the transmission band was determined. The transmission band of the filter was determined in wavelengths from the calibration curve of the diffraction grating (at the particular spectral order). A pair of spectral lines limiting the filter transmission band on both sides were determined from tables of spectral lines. A light source emitting the required reference lines was used for determining the line positions in scale divisions; a calibration curve (Fig. 2) was then constructed for each filter. The resulting curve was used to determine the width of the transmission band as well as the transmission-band maximum expressed in wavelengths.