Exercise 403

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Analysis of temperature dependence of refractive index of light by use of Abbe refractometer.

1. Theory

1. Reflection and refraction of light, definition of the absolute and relative refractive indices of light. Effect of total internal reflection. Dispersion. [1], [2], [3]
2. The construction and working principle of the Abbe refractometer [4], [5], [ ]

2. Devices

1. Two Abbe refractometers
2. Thermostat
3. Illuminating lamps

3. Method and course of the measurement

The refractive index of a liquid is a physical property that can often be used to assist in the identification of an unknown liquid. Refractive index is dependent on two factors: temperature and the wavelength of the incident light. The aim of experiment is to determine the dependence of refractive index on temperature. Refractive indices are measured using a refractometer. A thin film of a liquid is introduced between two prisms, the sample is illuminated, and the experimenter looks into an eyepiece. The field of view is divided in two halves: the dark and the bright. The illuminating lamp is adjusted until the best contrast between the light and dark halves of the visual field is obtained. The hand-wheel on the side of the instrument is then rotated until the dividing line between the light and dark halves of the visual field coincides with the centre of the crosshairs. (fig.1.) The scale is visible through the eyepiece, and the required refractive index can be read from the scale with accuracy $4 \cdot 10^{-4}$ in the range of value of refractive index from 1,3 to 1,42 and in the range from 1,42 to 1,7 with accuracy $2 \cdot 10^{-4}$. Scale has accuracy 0,001. The prisms are heated by the water with temperature fixed by a thermostat. It allows measurement of value of refractive index as a function of temperature. Two measurements for two liquids situated in two refractometers are carried out at the same time.

Fig.1. View trough the eyepiece of a correctly adjusted refractometer.

4. Experimental procedure

1. Switch on the lamp, open a window providing light to the system of prisms, half-open the mirror which is situated on the left side of refractometer and set it in order illuminate the scale.

2. Check the level of water in thermostat (if the level of water is too low or its temperature is higher than the room temperature, ask the technical instructor in order change it.

3. Observing the crosshairs and the scale of refractometer choose the optimal conditions of lighting and correct sharpness (by use of hand-wheel in top part eyepiece).

4. Turning the hand-wheel coupled with prism (situated in the left side of refractometer) set the boundary between the dark and bright halves of the visible field in the centre of the crosshairs. Look trough the eyepiece and adjust the illuminator so that you obtain the best possible contrast between the light and dark halves of the visible field. The illuminator is adjusted by simply moving it up and down.

5. If the borderline between the light and dark areas of the visible field appears as a coloured band, chromatic aberration (colour dispersion) is said to have occurred, and the borderline must be achromatize. Achromatization can be achieved by rotating the compensator dial located just below the eyepiece. Consult your instructor if necessary.

6. Read the temperature from thermometer (T_1 and T_2 for both liquids, respectively).

7. Set once again the boundary between the dark and bright halves of the field of view and read the refractive indices of the samples (n_1 and n_2, respectively) from the top scale that are visible through the eyepiece.

8. Set on the thermostate thermometer at the required temperature of measurement . Switch on the thermostat on H3 position, wait a moment until the control lamp goes out. Read the temperature of the investigated liquid on thermometer build into refractometer. Continue the measurements of refractive index according to recommendation contained in 5,6 and 7 above.

Use the measurement step equal to 5K, in the range of temperature from room temperature to 340K . During measurements thermostat should be switched on all the time.

9. Write the results of measurements in the table.

T_1 [K]	n_1	T_2 [K]	n_2

5. Preparation of the report

The report should be contain:

1. Short description of the method applied (without mentioning details of the experimental procedure).
2. Table with the measured values.
3. Calculations. For both liquids find the coefficients n_0, a and b of the formula

$$n = n_0 + aT + bT^2$$

   which describes approximate dependence of refractive index on temperature by use of least square method.
4. Plots of the dependence of refractive index on temperature T.
5. Discussion of the obtained results and possible origins of experimental errors.

6. References

[1] B. Jaworski, A. Dietłaf, L. Miłkowska, *Kurs fizyki*, PWN, Warszawa, 1984.

[2] M. Skorko, *Fizyka*, PWN, Warszawa, 1973.

[3] S. Szczeniowski, *Fizyka doświadczalna*, cz. 4, PWN, Warszawa, 1980.

[4] J. Karniewicz, T. Sokołowski, *Podstawy fizyki laboratoryjnej*, skrypt PŁ, 1996.

[5] H. Szydłowski, *Pracownia fizyczna*, PWN Warszawa, 1994.