Dispersion

The refractive index not only depends on the material, but also on the light's wave length: For light with a shorter wavelength we can usually observe a stronger refraction than for light with a long wavelength. This phenomenon is called *dispersion*.

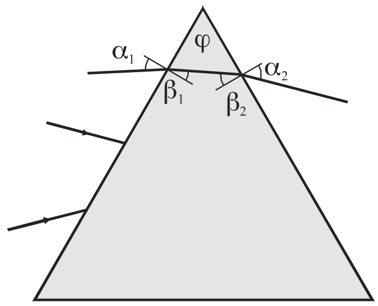
A typical light source emits light composed of different wavelengths. The spectrum can be *continuous* (as for a light bulb) or consist of several spectral lines (*discrete spectrum*). The latter can be analysed with a glass prism.

Goals: You are confronted with a measuring device that was very important in the history of atomic physics. You carry out careful measurements with a high precision.

Preparation:

i. Show that for a pencil of light hitting the prism's *refractive edge* the light rays reflected on the two sides form an angle $\gamma = 2 \cdot \varphi$.

ii. Sketch the optical path through the prism for the incoming light rays in the figure. Show that the total deflection is $\delta = \alpha_1 - \beta_1 + \alpha_2 - \beta_2$ and that the *refractive angle* is $\varphi = \beta_1 + \beta_2$.

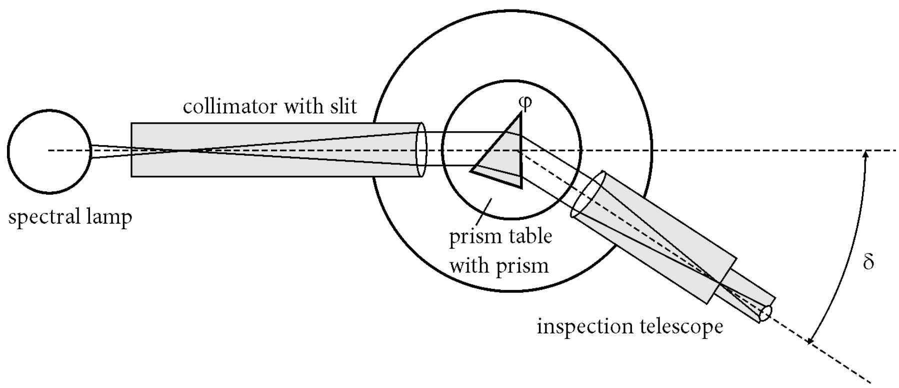


iii. The total deflection is smallest when the light ray passes through the prism on a symmetrical path (*minimum deflection*). Prove the following relation for this situation:

$$\sin \frac{\delta + \varphi}{2} = n \cdot \sin \frac{\varphi}{2}$$

Devices:

- Low-pressure mercury lamp
- Goniometer (see figure below)
- Glass prism
- Diffraction spectrometers
- Various light sources



Procedure:

a Before inserting the prism determine the undeflected light ray's angular position on the goniometer.

b Record the number of the prism in your journal.

c Face the prism with its refractive edge to the collimator and determine the angular positions of the two directly reflected rays (single white lines).

d Place the prism as in the figure above and find the (coloured) spectral lines in the telescope.

e Adjust the prism for minimum deflection of the first spectral line and read the angle from the goniometer.

f Repeat the measurement for the spectral lines you can assign to the ones in "Formeln und Tafeln" (p 176). Regularly adjust for minimum deflection before reading the angle.

g Turn the prism into the symmetric position and repeat the measurements on the other side of the incident ray.

h Investigate the spectra of different light sources. Sketch them in your journal.

Analysis:

1. Calculate the refractive index for every measured spectral line.
2. Graph the dispersion curve $n(\lambda)$ in a diagram.
3. The table below lists the refractive indices at different wavelengths for several typical varieties of glass (source: Handbook of Chemistry and Physics; 50th Edition). Determine the refractive indices at the same wavelengths from your diagram and decide whether it could be one of the glasses in the table.

Wavelength	**434 nm**	**486 nm**	**589 nm**	**656 nm**
zinc crown glass	1.528	1.523	1.517	1.514
crown glass (high dispersion)	1.533	1.527	1.520	1.517
light flint glass	1.594	1.585	1.575	1.571
heavy flint glass	1.675	1.664	1.650	1.644

4. What are the qualitative differences between the spectrum of a spectral lamp and that of a light bulb? At what wavelengths do the spectra end? What are the possible explanations for these limits? Which one is correct?

Requirements: If you do not write a report on this experiment, work at least on steps 1 and 2 of the analysis. The complete interpretation is required for a report.

Hand in your report or interpretation and the lab journal by Friday, 19 November 2010.