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FINDING OPTICAL DISPERSION OF A PRISM WITH APPLICATION OF MINIMUM DEVIATION ANGLE MEASUREMENT METHOD

1. Fundamentals

Optical dispersion D_n of a material is the phenomenon in which refraction index n varies with different wave frequencies ν (sometimes, based on the dependence $\nu = c/\lambda$, one speaks of dependence of n on the wavelength λ. However, one has to remember that wavelength depends on the media where the wave travels, by contrast, the frequency is the unique feature of the wave):

$$n = f(\nu) \text{ or } n = f(\lambda) \tag{1}$$

To understand the mentioned above dispersion definition, we have to learn what the refraction index is – why it depends on the wave frequency and what the measure of material dispersion is. Moreover, the experiment requires the knowledge on the prism and how it works and how to apply the method of finding the minimum deviation.

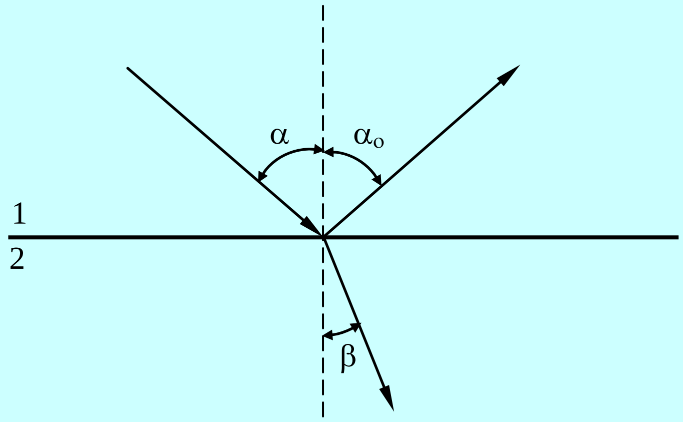

Fig.1. Refraction and reflection of rays at the boundary of two isotropic media.

Light refraction phenomenon is the change in direction of beam path (in the language of geometric optics) or the change in direction of light wave propagation (in the language of wave optics) when it crosses a boundary of two media. This phenomenon and related to it reflection phenomenon are managed by the laws known as geometrical optics laws. Let's recall them: When the light hits the boundary of two isotropic material media*), the transmitted (refracted) wave and the reflected wave appear. Three vectors describing wave propagation directions are in the same plane called plane of incidence (see fig. 1) and direction of propagation of these waves fulfills following formulas:

1. The angle of reflection α_0 is equal to the incidence angle α:

$$\alpha = \alpha_0 \tag{2}$$

2. The ratio of the sine of the angle of incidence and the sine of the angle of refraction is equal to the ratio of velocities v_1 and v_2 in two media and is constant for a given pair of two media and for a given wavelength. This value $n_{2/1}$ is called **refractive index of one medium with respect to another**:

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* Isotropic medium has identical physical properties in all directions. Properties of anisotropic media depend on the analyzed direction; in particular, light refraction index varies with orientation of incident light with respect to the optical axis of a medium and results in phenomenon called "birefringence". Anisotropy can be caused artificially, for example by applying an external force – this phenomenon is a basis for a wide range of practical applications so-called elastooptics (real construction models, sensors).

$$\frac{\sin\alpha}{\sin\beta} = \frac{V_1}{V_2} = n_{2/1} \quad , \qquad (3)$$

where α, β and α_0 **are the angles between direction of the waves: incident, refracted and reflected respectively and the normal of the boundary between media 1 and 2** (see fig. 1). The law described with the formula (3) is known as **Snell's law**.

If a light of a wavelength λ comes out from vacuum, where the speed of light has the known value c, independent of wave frequency, into the medium in which the speed of light is equal v(λ), the formula (3) can be rewritten in a form expressing **definition of an absolute light refractive index n(λ):**

$$n(\lambda) = \frac{c}{V(\lambda)} \qquad (3a)$$

Explanation of light refraction and reflection phenomena and deriving the laws managing these phenomena (geometrical optics law) can be done in various ways, for example:

- based on Fermat's principle,
- based on Huygens-Fresnel principle,
- based on Maxwell's electromagnetic theory.

In all these divagations we take the assumption that the light propagation speed varies with neighboring media. Because of technical difficulties, the experimental confirmation of this assumption was impossible. It was eventually proven by Foucault in 1850.

In this manual, we are going to derive the laws of geometrical optics based on Fermat's principle. Fermat's principle is usually stated as the path taken by a ray of light in traveling between two points requires either a minimum, a maximum or the same time (in a stationary case). Fermat's principle is a particular case of a very general principle ruling in the nature, stating that all the processes follow optimum paths.

With the reference to ray paths, this can be described with a formula:

$$\int n ds = extremum \qquad (4)$$

where: n - light refraction index for a chosen medium, s - geometrical path. **The product L=n·s is called an optical path.**

Thus, according to Fermat's principle, when a light ray travels, its optical path is being optimized. With application of simple geometrical constructions one can show that optical paths traveled by a ray being reflected or refracted in a homogeneous media, are the shortest of possible paths linking two chosen points A and B.

Let's analyze this based on the example of refraction law (see fig. 2). We have points A and B given in two media 1 and 2 and a ray APB linking both of them. Based on known mechanics formula we can write that the time required for traveling A-P-B path is given with a formula:

$$t = \frac{s_1}{V_1} + \frac{s_2}{V_2} \; . \qquad (5)$$

Once we introduce the optical path concept and we consider the dependency (3a), formula (5) is now:

$$t = \frac{n_1 \cdot s_1 + n_2 \cdot s_2}{c} = \frac{L}{c} \; , \qquad (5a)$$

Where $L = L_1 + L_2$ is the overall optical path of wave front traveling from A to B, and L_1 and L_2 are optical path traveled in medium 1 and 2. We should not confuse the optical path with the geometrical path equal to $s = s_1 + s_2$. Optical path is equal to geometrical path multiplied by the refraction index of the medium.

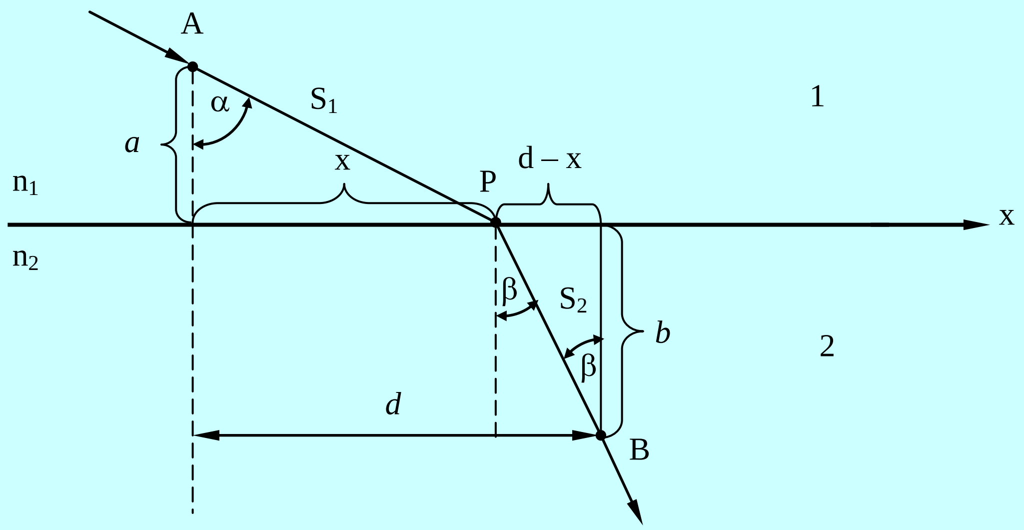


Fig.2. The ray originating from point A is refracted on the media boundary at point P and reaches point B.

Refraction indexes n_1 and n_2 are absolute light refraction indexes for a wave of a frequency ω in medium 1 and 2.

Based on Fermat's principle, we know that optical path has to be optimum, so P point has to be located in such a place on X axis so that derivative of optical path L with respect to x coordinate was equal to zero, so:

$$\frac{dL}{dx} = 0 \qquad (6)$$

With application of geometrical dependencies shown in fig. 2 we can write:

$L = n_1 \cdot s_1 + n_2 \cdot s_2 = n_1\sqrt{a^2 + x^2} + n_2\sqrt{b^2 + (d-x)^2}$. Differentiating, we obtain:

$\frac{dL}{dx} = \frac{1}{2} n_1 (a^2 + x^2)^{-\frac{1}{2}} 2x + \frac{1}{2} n_2 [b^2 + (d-x)^2]^{-\frac{1}{2}} 2(d-x)(-1)$, what can be written as:

$$n_1 \frac{x}{\sqrt{a^2 + x^2}} = n_2 \frac{d-x}{\sqrt{b^2 + (d-x)^2}} \,. \qquad (7)$$

Formula 7, with respect to the trigonometric dependencies, is the equation describing the refraction law (3):

$$n_1 \cdot \sin\alpha = n_2 \cdot \sin\beta \,. \qquad (7a)$$

There are as many ways of deriving geometrical optics law as many there are recognized light theories. Any light theory can only be recognized under condition it can explain the experimentally verified laws of reflection and refraction.

Light refraction index in a medium depends on the light wave frequency (see formula (1)). This phenomenon, as it was stated above, is called light dispersion, characteristic for a chosen material. In spectral ranges, for which a chosen material is translucent, an increase of light refraction index is being observed as light frequency is being increased. In the ranges where a medium absorbs light - so-called abnormal light dispersion is being experienced, it means decrease of light refraction index with light frequency is being increased.

To explain light dispersion, we make an assumption that electrons, atoms and particles of a medium through which the light wave is traveling, react in a various way to magnetic field that forces them to vibrate, as they have specific frequencies of their own vibrations ν_0 which may be different from the electromagnetic wave frequency *v*.

Let's analyze the example of interaction of electromagnetic waves with valence electrons of a medium through which these waves pass. These waves belong to a visible range. Electrons have their own specific frequencies ν_0. Incident wave forces vibration of frequency v, but the amplitude and phase of forced vibrations of electrons (and in consequence the secondary waves they send) depend on the difference between the own electron vibrations frequency ν_0 and the frequency of the incident wave ν. If a wave hits perpendicularly the plane medium boundary, amplitudes and phases of vibration of all electrons with which wave interacts are the same in a very thin layer (comparable to wavelength) adhering to the boundary of the medium. The vibrations of the analyzed layer create a secondary plane wave, coherent with incident wave, but shifted with respect to it in phase of φ angle expressed with a formula:

$$\operatorname{ctg}\varphi = \frac{\beta \nu_o}{(\nu^2 - \nu_o^2)} \qquad (8)$$

where β denotes the damping ratio.

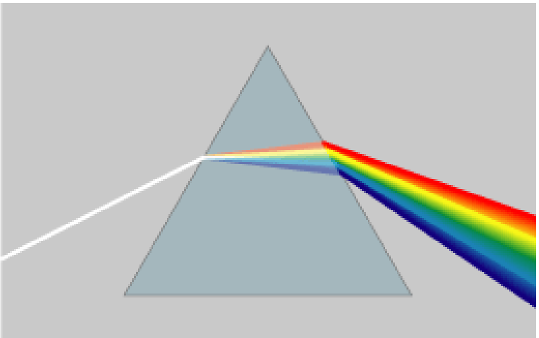
The output wave, created in this thin layer as a result of superposition of the incident and the secondary wave, is shifted in phase with respect to the incident wave at a certain angle dependent on the amplitude of the secondary wave and the phase shift between it and the primary wave. In each subsequent layer, sorted out in mind in the same way, there is a similar phase shift of the output wave with respect to the incident wave. Thus, as the output wave propagates in the medium, the phase changes with respect to the primary incident wave by an angle proportional to the path traveled by the wave in the medium. In consequence, we speak of the velocity of the phase shift or **the phase velocity v of a wave**. Taking into consideration the described above properties of wave propagation in media, we can say that any wave propagates in any medium with the phase velocity different from the phase velocity c in the absence of the medium. As we see from the formula (8), the phase change, and therefore the phase velocity, depends on the difference between the frequency of incident wave and the frequency of proper vibrations of electrons of the medium. The phase velocity of waves of a different frequency will be therefore different. As the white light is a mixture of waves of various frequencies, each component wave will propagate at a different velocity.

According to the formula (3a), each component of the white light will refract with a refraction index of a different value. This phenomenon is called "dispersion". **The commonly used dispersion measure D_n of any medium** is a difference of refraction indexes of K (violet color) and A (red color) lines (Fraunhofer's definition):

$$[D_n] = n_F - n_C \qquad (9)$$

so this is the difference of light refraction indexes for a specific difference of wavelengths.

The dispersion phenomenon can be experienced when a white light beam is passing through a prism (see Appendix). As each component of the white light has a different refraction index – and the angle at which the prism bends a ray depends on the light refraction index – therefore the prism bends the light rays of different wavelength in a different way. Light of longer wavelengths – for example red – is less bend by the prism than the light of shorter wavelengths – for example violet. In consequence, we will see a characteristic rainbow in the screen located behind the prism which is a result of separation of waves of different frequencies.



2. Experiment

The goal of this experiment is to determine the apex angle of the prism and to find its optical dispersion and its resolving power with application of the minimum deviation method.

2.1. Finding the apex angle of the prism

The method of finding the apex angle of the prism applied in this experiment uses geometrical optics law referring to light reflection phenomenon (see formula 2). The principle is shown in fig 3.

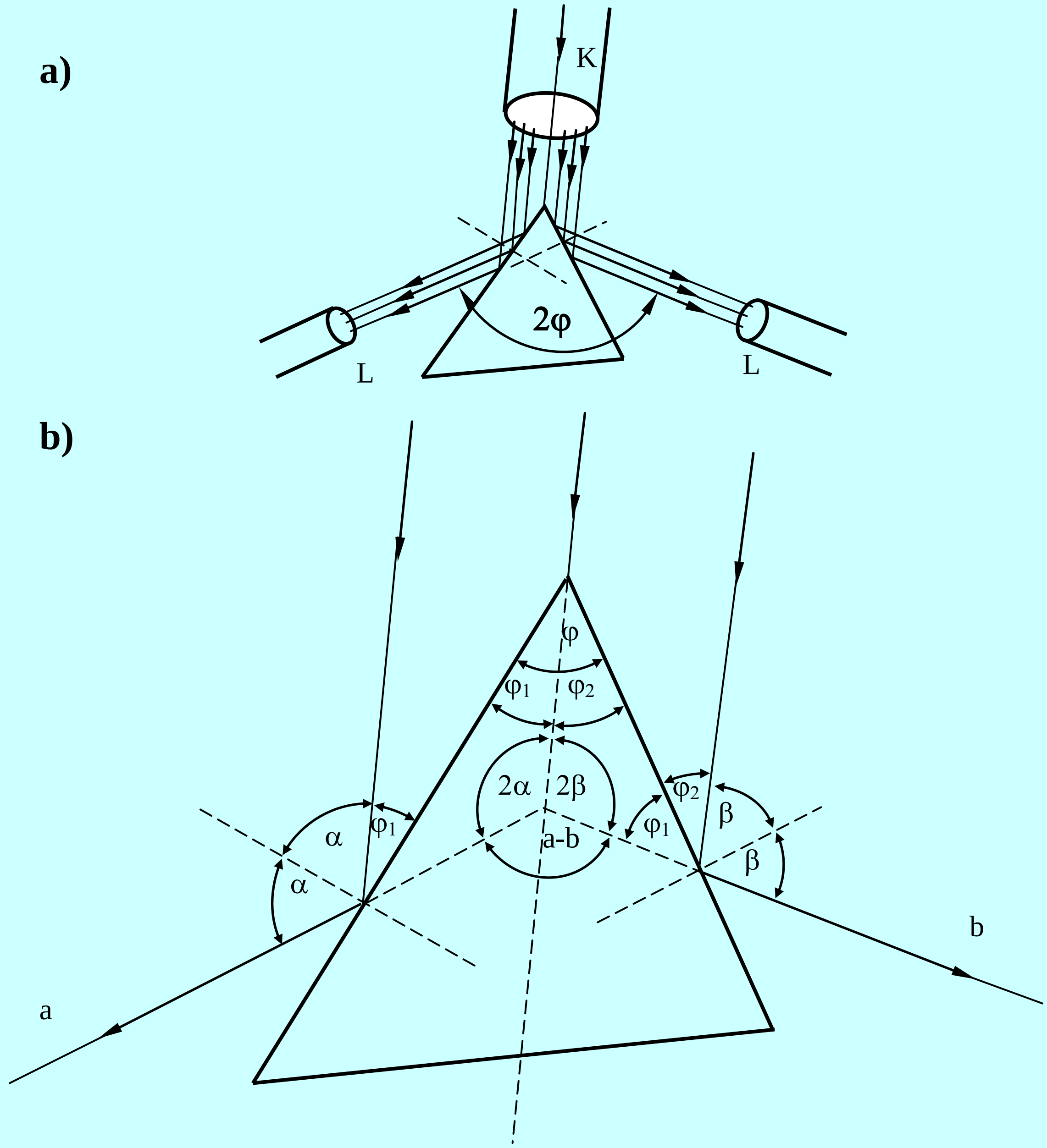


Fig. 3. Finding the apex angle of the prism: a) reflection of rays from the walls of the prism; b) illustration of geometrical divagations.

We set the prism in such a way that the apex angle φ is located in front of the collimator and it is illuminated with a parallel beam. We observe two beams reflected from the prism walls and we determine angle location of the viewfinder a and b corresponding to these beams. As it is seen in the fig. 3b:

$$a - b = 360^\circ - 2\alpha - 2\beta , \quad \alpha = 90^\circ - \varphi_1, \; \beta = 90^\circ - \varphi_2 .$$

Then we obtain a – b = 360˚ - 2(90˚- φ_1) – 2(90˚ - φ_2) , and then:

a - b = $2\varphi_1 + 2\varphi_2 = 2\varphi$, so:

$$\varphi = \frac{a-b}{2} \quad . \qquad (10)$$

Application of formula (10) enables us to figure out the value of the apex angle φ of the prism at known angular locations a and b of the viewfinder through which we observe the beams reflected from the prism walls.

2.2 Finding the refraction index with application of the minimum deviation method

Dependence of deviation angle ε of a beam passing through the prism on the angle of incidence α at the prism wall is derived based on the following divagation (see fig. 4a).

Let's think of behavior of a parallel beam of monochromatic (single color) light. This passing can be illustrated in a vertical cross-section. The ray hits the side wall I of the prism at an angle α_1, refracts at an angle β_1 (see formula (3)), hits the side wall II at an angle β_2 and goes out of the prism at an angle α_2 with respect to the normal to the wall II, creating the angle ε with the direction of the incident ray. This angle is called "a deviation angle".

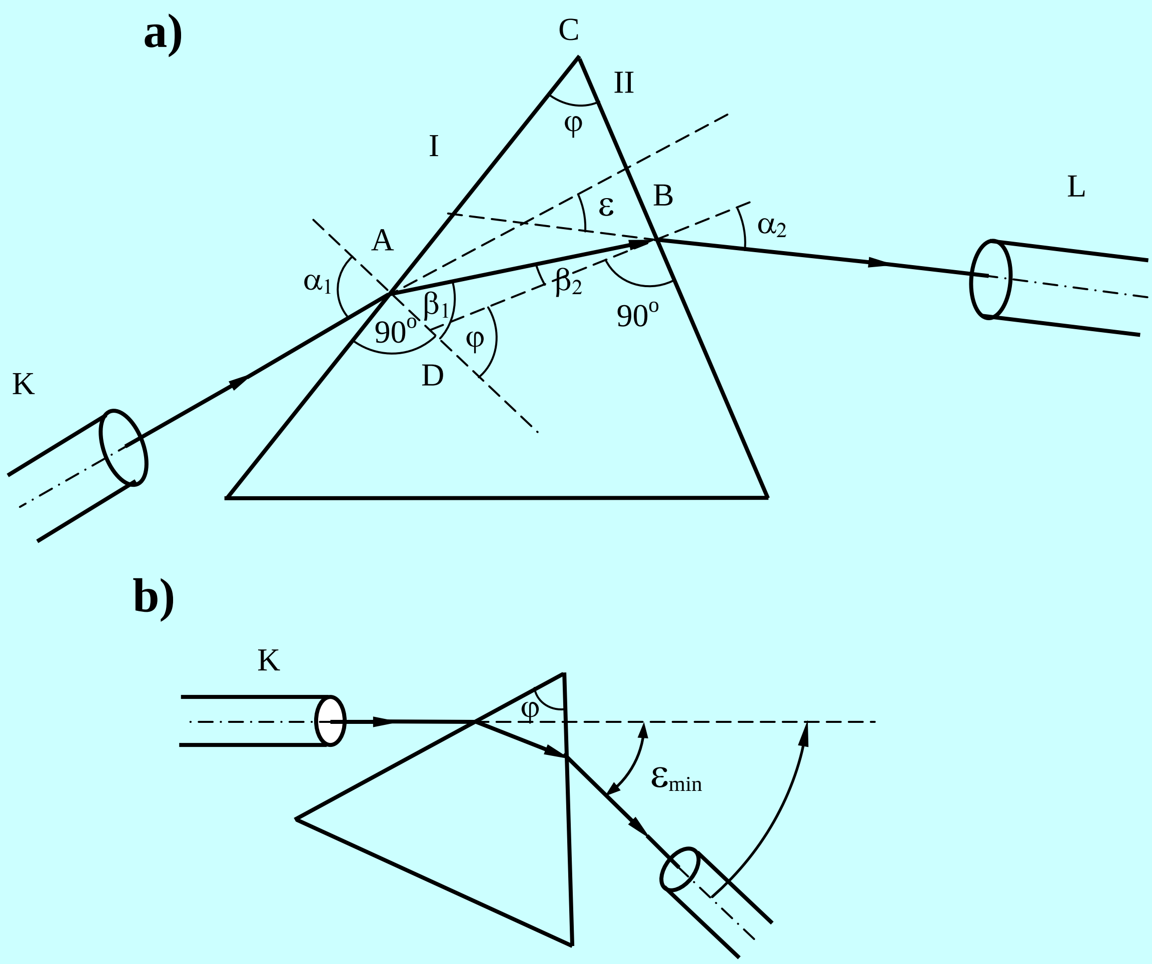


Fig.4. Path of monochromatic light in a simple prism:
a) geometrical divagations;
b) setting the viewfinder at an angle of minimum deviation ε_{min}.

Having in mind the fact that the external angle in the ABD triangle is equal to the apex angle φ of the prism (this angle has arms perpendicular to prism walls), we can easily derive the following geometrical dependencies:

$\varphi = \beta_1 + \beta_2$ (11a)
$\varepsilon = (\alpha_1 - \beta_1) + (\alpha_2 - \beta_2)$ (11b)
$\varepsilon = \alpha_1 + \alpha_2 - \varphi$ (11c)

The deviation angle ε depends on the value of the angle of incidence α_1. If we observe the spot of light deviated by the prism and we rotate the prism to change angle α_1, we will be able to notice that the spot reaches the point near to the location that would be reached if the prism was removed. **Then the spot regresses despite the fact that the prism is still being rotated in the same direction.** There exist therefore such an angle of incidence α_1 at which the angle of deviation is minimum ε - it happens [2] (see appendix) when we have a so-called **"symmetric course"**, for which $\varepsilon_1 = \alpha_2 = \alpha$ and $\beta_1 = \beta_2 = \beta$.

Based on (11) relations, we can write for a symmetric course:

$$\varepsilon_{\min} = 2\alpha - \varphi; \Rightarrow \alpha = \frac{\varepsilon_{\min} + \varphi}{2}; \qquad \varphi = 2\beta; \Rightarrow \beta = \frac{\varphi}{2} \tag{12}$$

Plugging the above dependencies to the formula (3), we obtain the formula which is important for the presented method:

$$n = \frac{\sin\frac{\varepsilon_{\min} + \varphi}{2}}{\sin\frac{\varphi}{2}} \tag{13}$$

This formula enables us to determine refraction index when one knows the apex angle of the prism φ and the minimum deviation angle ε_{min} for a given wavelength λ. These values can be measured with spectrometers.

3. Measurements

3.1. Preparation of the spectrometer for measurements

Before starting the main measurement one has to adjust the spectrometer according to the instructions located at the experimental setup or according to the supervisor's explanations.

3.2. Measurement of the apex angle of the prism

We set the prism is such a way that the apex angle was located in front of the collimator and we observe through the viewfinder L images of the slit created by the rays reflected from the prism wall (fig.3a). The angle between directions L of the reflected light rays will be equal to 2φ. Therefore, to determine the apex angle of the prism, we set the viewfinder for observation of the beam reflected from first wall of the prism and we read the viewfinder location ("a" degrees), and then we observe the image of rays reflected from the second wall and we write down "b" location. The apex angle is equal to the half of the difference of these two readouts. During the measurement you have to make sure that the crossing of the ruler lines in the viewfinder was going through the center of the slit image that should be as narrow as possible.

The results have to be written down in Table 1, prepared accordingly in your laboratory log. The precision of the measurement has to be determined during the experiment as they are necessary for preparation of the measurement data and determination of the calculation uncertainties. Apart from the instrument precision one has to consider the precision of setting the cross lines in the centre of the slit. The accuracy of the measurement of the apex angle of the prism can be estimated as:

$|\Delta\varphi|$ = readout precision + ½ of the angular width of the slit image.

The results of estimations (in radians) have to be written down in the laboratory log.

3.3. Measurement of the minimum deviation angle

Adjust the table and viewfinder position to set them at the minimum deviation angle of the "red" fringe (fig. 4b) for the apex angle φ that has been found previously. Rotate the table to change the light incidence angle. At a certain position of the table (at a specific light incidence angle) fringe stops and returns with a further table rotation. Set the table position at the turning point as precisely as possible (using the table adjustment knob). The table position corresponds now to the minimum angle ε_{min} of the deviation of the beam passing the prism. At this table position, set the viewfinder in this way that the cross lines in the viewfinder were located in the middle of the fringe. Write down the location of the viewfinder read out from the nonius. Repeat the measurement three times.

Once the described above measurements are completed, remove the prism (the table has to be locked), set the viewfinder in front of the collimator and read the noniuses once again. The rotation angle from the position corresponding to the minimum deviation to the location in front of the collimator equals to the angle of the minimum deviation ε_{min}. Repeat the measurement three times. The results of all the measurements are to be written in the log in table 2.

Next, perform the analogical measurements for the brightest lines. Wavelengths in [nm] corresponding to this lines can be found in the chart at the measurement setup or in physical tables. The results are to be written in the log, in table 2.

When measuring the minimum deviation angle, one can notice that in the proximity of turning point, regardless the table rotation, the fringe seems to be stationary – the eye does not notice changes in its location. The table rotation between the moment when the fringe stops and the moment when it starts “returning” is called “a dead range”. The uncertainty of the minimum deviation can be estimated as:

$$|\Delta\varepsilon_{min}| = \text{readout precision} + \frac{1}{2} \text{ of the angular width of the slit image.}$$

Write down the estimation results (in radians) in the laboratory log.

4. Results

1. Basing on the formula (10), calculate the apex angle of the prism φ and report the result in table 1.
2. Calculate angles of minimum deviation ε_{min} for subsequent neon lines as differences in angular location of the viewfinder (the average value of three measurements) corresponding to the turning point for a given line and to the location in front the collimator (the average value of three measurements). Write down the results in table 2.
3. Basing on the formula (13), figure out light refraction indexes n_λ and their uncertainties $u(n_\lambda)$ for subsequent lines.
4. The measurement uncertainty n depends on the uncertainties of measurements φ and ε_{min}. This is the uncertainty that has to be calculated based on the knowledge of standard uncertainties $u(\varphi)$ and $u(\varepsilon_{min})$.
5. When performing calculation, do not forget to use radians [rd] to express the angle uncertainties.
6. Draw a curve of dependence of light refraction index n from the wavelength λ, a so-called dispersion curve and calculate dispersion [D_n] (formula 9).
7. In the conclusion part, compare obtained results to the table values.

5. Questions

1. What is the light refraction phenomenon?
2. How are the relative absolute and the absolute light refraction indexes defined?
3. How does light acts on the simple prism?
4. What is the dispersion of a material medium?
5. How can the apex angle of the prism be measured?
6. Describe the method of finding light refraction index with application of the minimum deviation angle?

6. References

1. D. Halliday, R. Resnick, J. Walker, Fundamentals of Physics, Wiley (2011), part 4, Chapter 33-8.

APPENDIX

The prism is made of a transparent medium limited by two flat surfaces that have an angle φ between them. The angle is called the apex angle of the prism.

Complex prisms, created for special purposes, can be used to break a light beam up, to change a light direction without splitting it or to polarize light.

Influence of a prism on a white light beam

A simple single prism always breaks white light up and changes its path. Its action is based on the light dispersion phenomenon or different values of light refraction indexes for various light wavelengths v (see definition 1).

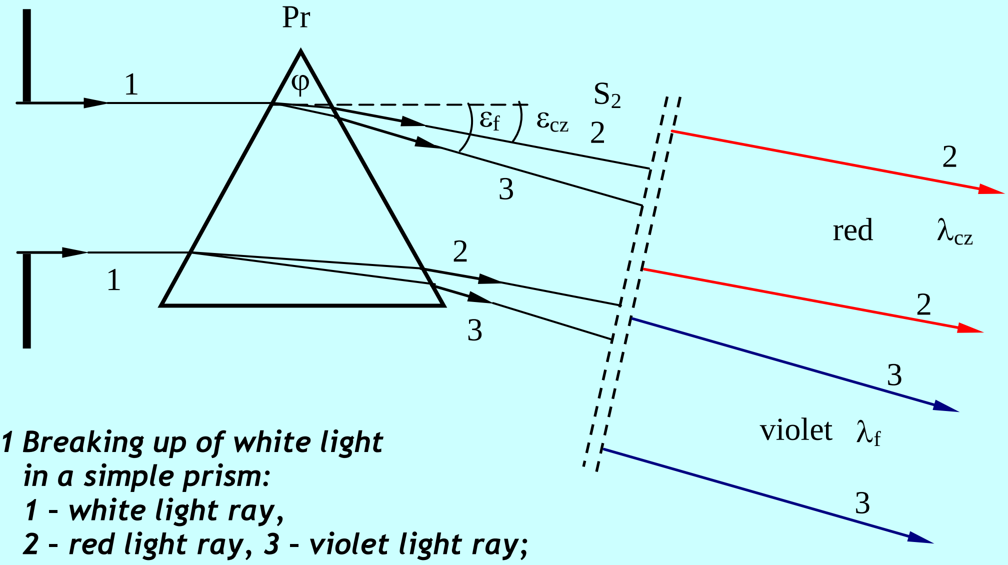


Fig.A.1 Breaking up of white light in a simple prism:
1 - white light ray,
2 - red light ray, 3 - violet light ray;
φ - prism apex angle, ε - ray deviation angle.

Each of components of a parallel white light beam (which is a mixture of waves of different frequencies *v*), hitting one of the prism's walls creating the apex angle, refracts on it at a different angle and travels with a different velocity inside the prism, passes the prism and while leaving it, it refracts once again, creating a colorful divergent beam (see fig. A.1).

A path of a monochromatic light ray in a prism

A monochromatic light ray, while travelling along a path inside a prism refracts from the primary path at an angle ε. The angle depends on the angle of incidence on the prism wall α_1 and light refraction index for a given wavelength n_λ (or frequency n_v). There exists an angle α_1 (for a given prism) for which ε angle reaches a minimum value ε_{min}. It can be proven that for this specific angle monochromatic light ray travels in the prism perpendicularly to the bisector of the apex angle (it means in a "symmetric way", which results in the fact that the angle of incidence α_1 and the angle of emergence α_1 are equal ($\alpha_1 = \alpha_2$)). This property of the prism is a base for the method of finding the optical dispersion of material D_n known as the method of measurement of the angle of minimum deviation ε_{min}.

The proof for condition of reaching by the deviation angle ε the minimum value can be done both on the geometrical and analytical way. Let's recall here the analytical proof [2]:

We differentiate the formula defining the dependence of the deviation angle ε on the angle of incidence α_1 (see fig.4 and formula 12c: $\varepsilon = \alpha_1+\alpha_2 - \varphi$) with respect to α_1:

$$\frac{d\varepsilon}{d\alpha_1} = 1 + \frac{d\alpha_2}{d\alpha_1} \quad , \quad \text{and for minimum: } \frac{d\varepsilon}{d\alpha_1} = 0 \, , \quad \text{so:} \Rightarrow 1 + \frac{d\alpha_2}{d\alpha_1} = 0 \qquad \text{(A1)}$$

Basing on the condition defining dependence between the apex angle of the prism and refraction angle β_1 and angle of incidence on the exit wall β_2 (see fig. 4 and formula 12b): $\beta_1 + \beta_2 = \varphi$, we find, by calculating the derivative with respect to α_1:

$$\frac{d\beta_1}{d\alpha_1} + \frac{d\beta_2}{d\alpha_2} = 0 \tag{A2}$$

But $\sin\alpha_1 = n \cdot \sin\beta_1$ and $\sin\alpha_1 = n \cdot \sin\beta_1$ (see formula (3)). By differentiating these dependences with respect to α_1, we find:

$$\text{(a)} \quad \cos\alpha_1 = n \cdot \cos\beta_1 \frac{d\beta_1}{d\alpha_1} \quad \text{and (b)} \quad \cos\alpha_2 = n \cdot \cos\beta_2 \frac{d\beta_2}{d\alpha_1} \ . \tag{A3}$$

From the formulas (D1) and (D2) we have:

$$\frac{d\alpha_2}{d\alpha_1} = -1 \quad \text{and} \quad \frac{d\beta_2}{d\alpha_1} = -\frac{d\beta_1}{d\alpha_1} \ . \tag{A4}$$

Plugging the obtained dependencies (A4) into formula (A3(b)), we find:

$$\cos\alpha_2 = n \cdot \cos\beta_2 \frac{d\beta_1}{d\alpha_1} \ . \tag{A5}$$

By dividing side by side obtained dependencies (A5) and (A3(a)), we obtain:

$$\frac{\cos\alpha_2}{\cos\alpha_1} = \frac{\cos\beta_2}{\cos\beta_1} \ , \tag{A6}$$

where, after raising both sides to the power of two, we have:

$$\frac{1-\sin^2\alpha_2}{1-\sin^2\alpha_1} = \frac{1-\sin^2\beta_2}{1-\sin^2\beta_1} \ . \tag{A7}$$

By transforming the formula (A7), taking into consideration dependence (3), we obtain:

$$n^2\sin^2\alpha_2 + \sin^2\alpha_1 = n^2\sin^2\alpha_1 + \sin^2\alpha_2 \ , \tag{A8}$$

then, after the transformation we have:

$$\sin^2\alpha_2 = \sin^2\alpha_1 \ . \tag{A9}$$

Both α angles are positive and acute. Thus we have:

$$\alpha_1 = \alpha_2 \quad \text{and} \quad \beta_1 = \beta_2 \tag{A10}$$

By dividing both formulas (A3), taking into consideration (A10), we have:

$$\frac{d\alpha_2}{d\alpha_1} = -\frac{\cos\beta_2 \cdot \cos\alpha_1}{\cos\beta_1 \cdot \cos\alpha_2} \tag{A11}$$

By calculating the 2nd derivative of the formula (A11) with respect to α_1 and taking into consideration (A3) and (12c) we find that:

For $\alpha_1 = \alpha_2$ and $\beta_1 = \beta_2$ - second derivative $\frac{d^2\alpha_2}{d\alpha_1^{\ 2}} \rangle 0$ which means that we deal with minimum of deviation ε of the light right with the prism.

The resolving power of the prism R_λ i.e. the capability of resolving neighboring spectral lines of a wavelengths λ and λ +δλ is defined as:

$$R_\lambda = \frac{\lambda}{\delta\lambda} \ , \tag{A12}$$

is related to the diffraction phenomenon.

We know that if a light beam hits a slit, it is being diffracted. When the beam hitting the slit is parallel, then for the wavelength λ the angle of refraction φ, at which the first minimum is present is given by a formula:

$$\sin\varphi = \frac{\lambda}{d}, \qquad \text{(A13)}$$

where d is the slit width.

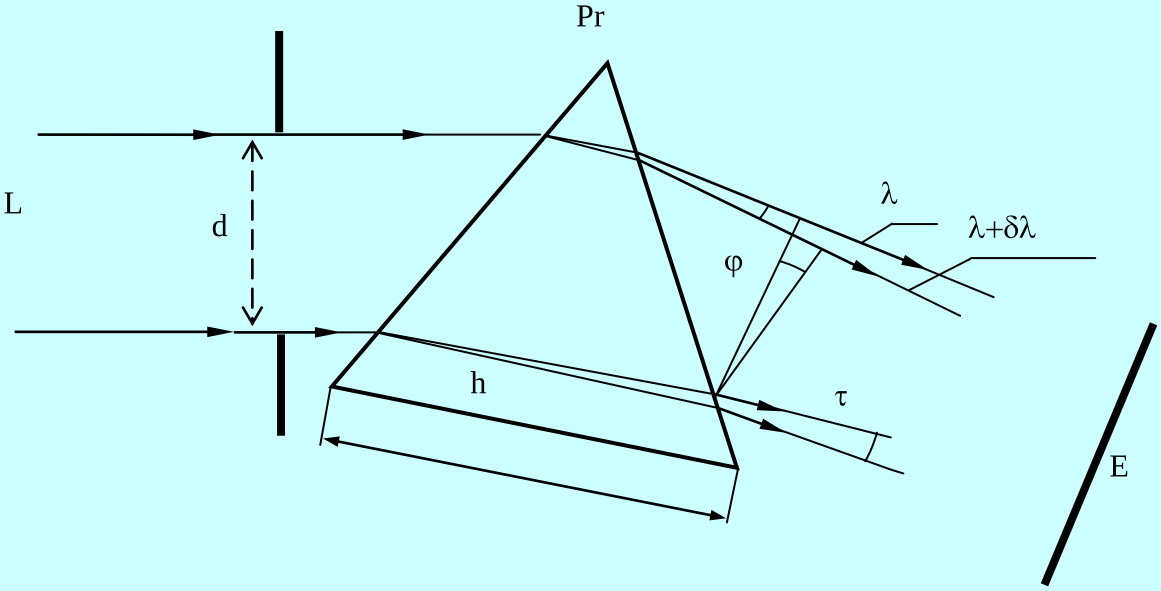


Fig.A.2. A setup for figuring out a resolving power of a prism:
L - light source, S_1, S_2 - lenses, Pr - prism, E - screen

Let's analyze the beam of a light hitting the prism at an angle of minimum deviation (fig. A2). The beam has a dimension limited by the dimension of the prism – the beam width plays a role of a slit, at which refraction takes place. Moreover, let's recall that the light incident on the prism consists of two beams: one of a wavelength λ and refraction index n and the second one of a wavelength λ + δλ and refraction index n + δn. For beams travelling near the base of the prism the difference of optical paths travelled by these two beams is δs = h·δ·n , where h – is the length of the prism base. The wave fronts corresponding to these beams will create the angle τ, and, as it is seen in fig A.3, a following formula is valid:

$$\sin\tau = \frac{\delta s}{d} = -\frac{h\delta n}{d} \qquad \text{(A14)}$$

There is a "minus" sign, because δn<0. The slit images created by these two beams will be separated when τ angle is at least equal to the υ angle, defining the distance between the central and the first minimum, created thanks to the light diffraction on the prism, which is a diaphragm of a width d. Thus, the condition of separation of two images will be obtained by comparison of (A13) and

$$\frac{-h\delta n}{d} = \frac{\lambda}{d}, \qquad \text{(A15)}$$

where we find the formula for the resolving power of the prism R (see A12):

$$R_\lambda = \frac{\lambda}{\delta\lambda} = -h\frac{\delta n}{\delta\lambda} = -h\cdot D_n \qquad \text{(A16)}$$

Based on formula (A16), one can see that the resolving power of a prism R_λ is proportional to the length of a prism h and the speed of change of refraction index with a change of a wavelength, or so-called medium dispersion or material dispersion D_n.