Protocol for Lab

Fundamentals

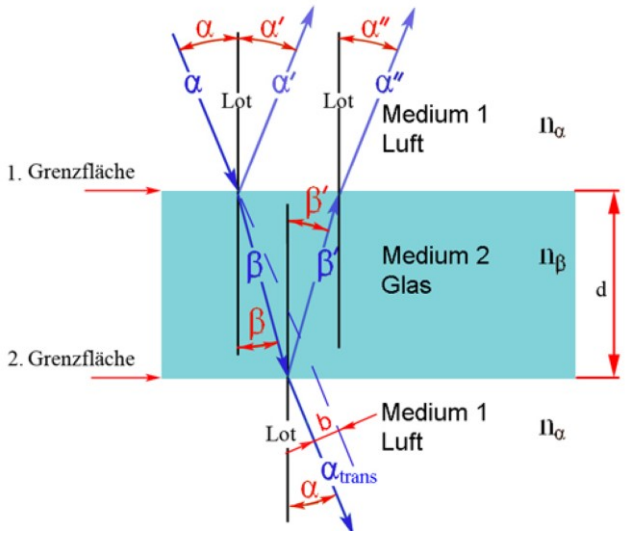
Content

1. Beam propagation, law of reflection, and Snellius law

1.1. Air-metal and air-plexiglass transition

a) The beam falls on the metal sample at the angle α (20°, 30°,..., 70°) to the perpendicular. Measure the angles of reflection α'. Please, use template V.0.

b) The beam falls on the plexiglass sample at the angle α (20°, 30°, ..., 70°) to the perpendicular. Measure the angles of reflection α' and refraction β. Please, use template 1.1.



c) Calculate the refractive index n_β for each angle and find an arithmetically averaged value.

d) Observe the reflected beam α" and describe its trajectory.

e) Explain the source of the beam α" coming out of the same side of the plane-parallel plate as the beam.

f) Compare the intensity of the beam α and α".

1.2. Air-water

a) The beam falls on the sample at the angle α (15°, 20°, 25°, 30°, 40°) to the perpendicular. Measure the refracted angle γ. Calculate the refractive index n_γ for each angle and find an arithmetically averaged value.

1.3. Plexiglass-water

a) Couple the laser light into the plexiglass at the angle β (10°, 15°, 20°, 25°) to the perpendicular. Measure the refracted angle γ_{water}.

b) Calculate the values of refractive index $n_{\beta\gamma} = \frac{n_\gamma}{n_\beta}$ for the transition plexiglass-water. Find an arithmetic averaged value.

1.4. Parallel shift

a) Measure and calculate the parallel shift of the beam propagated through a plane parallel plate for the angles α (20°, 30°, 40°, 50°). Please, take the value of angle $\beta_{measured}$ from the test 1.1. The plate thickness d is 58.5 mm.

b) The parallel shift is measured perpendicular to the beam. On which factors does the parallel shift depend? Please, explain!

$\alpha_{incid.}$	$\beta_{meas.}$	α_{output}	$b_{meas.}$	$\sin\beta_{calc.}=\frac{\sin\alpha}{n}$	$\beta_{calc.}$	$\alpha-\beta_{calc.}$	$\cos\beta_{calc.}$	$b_{calc.}=d\frac{\sin(\alpha-\beta_{calc.})}{\cos\beta_{calc.}}$
20°								
30°								
40°								
50°								

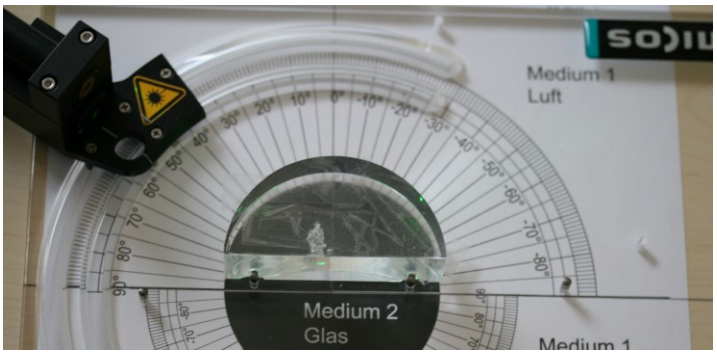
1.5. Total internal reflection with plexiglass plate

a) Calculate the angle α_2 from the angle $\alpha_1 = 25°$. Calculate consequently $\beta_1, \beta_2, \beta_3$ and β_4 in addition to α_2. Explain your calculations. Elaborate nβ from the test 1.1.

b) Why does the total internal reflection phenomena take place at the transition β_2 to β_3 ?

c) In which technical and medical devices the total internal reflection effect is used?

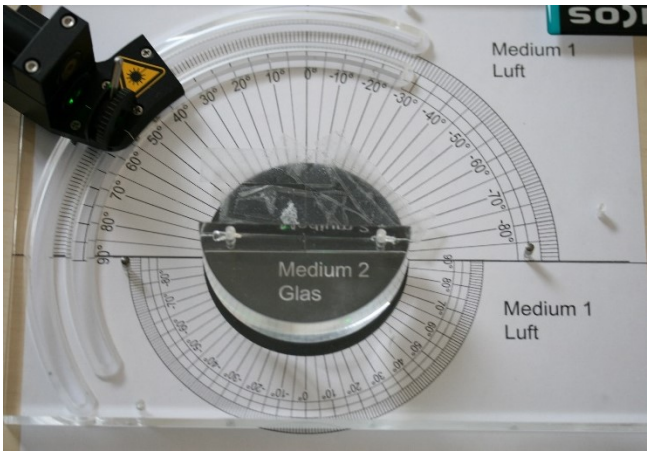
1.6. Total internal reflection with plexiglass arc forms



a) Measure the critical angle of total internal reflection with the plexiglass semi arc! Calculate refractive index of the plexiglass using the expression for total internal reflection.

b) Compare the results of refractive index measurement with the previous tests with plexiglass plate.

1.7. Brewster angle measurement with plexiglass semi arc forms



a) Insert a polarizer into the laser holder!

b) Measure the external Brewster angle (air -> glass) with the plexiglass semi arc, using template V 4.1, V 5.1. Calculate refractive index of the plexiglass!

c) Compare the results of refractive index measurement with the previous tests with plexiglass plate!

2. Propagation through prism and prism dispersion

a) The incident angle to the perpendicular is α_1 (10°,20°, 40°, 50°). Observe the beam propagation! Explain the observed picture! Please, use template 2 for this measurement!

Please, use the yellowish prism with opaque top surface for tasks 2b) and 2c), which can be found in the blue boxes. If you have green and red boxes only, please ask your colleagues with a blue box to share it!

b) Set the incident angle at the angle of minimum inclination (beam propagates parallel to the base of the prism inside). Please, use template V4.2 for this measurement. Repeat measurements with another wavelength (another laser). Calculate prism dispersion using expression:

$$dispersion = \frac{\partial \alpha}{\partial \lambda} \approx \frac{\alpha_{red} - \alpha_{green}}{\lambda_{red} - \lambda_{green}}, n_{532nm} = 1.746 > n_{633nm} = 1.733$$

c) Find incident angle for the minimum angle deviation for red and green lights and calculate refractive index according to expression

$$n_\beta(\lambda) = \frac{\sin\frac{\alpha_{\min} + \gamma}{2}}{\sin\frac{\gamma}{2}}$$

Here, γ is the prism angle.

3. Diffraction

a) Measure diffracted light in the first and second order at the perpendicular incidence for red and green light and calculate grating dispersion according to the expression

$$dispersion = \frac{\partial \alpha}{\partial \lambda} \approx \frac{\alpha_{red} - \alpha_{green}}{\lambda_{red} - \lambda_{green}}.$$

4. Transmission through polarizers and birefringent crystals

Please, use <u>either</u> the green or red laser for the following measurements! Don't forget to note which laser you used!

a) Place first polarizers into the slot just after the laser and observe minimum and maximum transmitted intensity at the polarizer rotation. Set the angle for maximum transmitted intensity.

b) Place the second polarizer into the slot for analyzer and observe minimum and maximum intensity of light, propagated through the two polarizers. Set the analyzer for minimum transmitted intensity. Adjust both polarizer and analyzer in order to get minimum transmitted intensity.

c) Place the birefringent crystal between the polarizer and analyzer and observe increase of the transmitted intensity. Rotate the analyzer in order to minimize again the transmitted intensity. Write down your results according to V.6.2.

d) Change the birefringent crystals and repeat the measurements. Observe polarization rotation in right and left directions. Write down your results according to template V.6.2

Final Questions

Please, make sure you have answered the following questions within your report:

a) What is Snellius law?
b) Which laws do you need in order to explain beam propagation?
c) Explain the effect of the Brewster angle!
d) Explain the effect of birefringence and polarization rotation!
e) Explain the effect prism dispersion!
f) Explain the effect of grating dispersion!
g) Give examples in nature, physics and technique where total internal reflection occurs.
h) Describe the beam propagation through a prism!
i) Describe the beam propagation through the concave and convex lenses.