Optics

Velocity of light

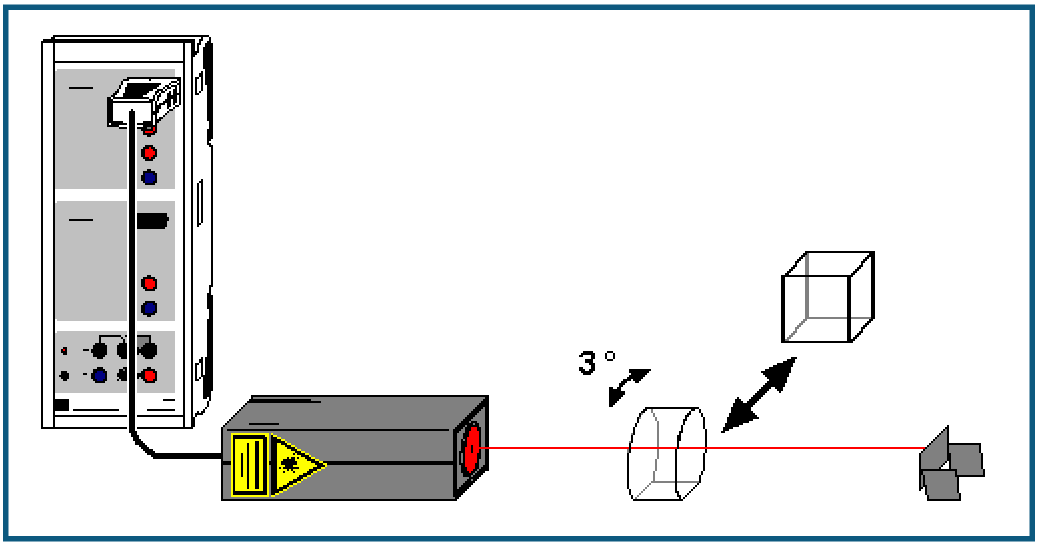
Measuring with an electronically modulated signal

Determining the velocity of light for different propagation media - measuring with the laser motion sensor S and CASSY

Description from CASSY Lab 2

For loading examples and settings, please use the CASSY Lab 2 help.

Velocity of light in various materials



can also be carried out with Pocket-CASSY and Mobile-CASSY

Safety note

Mind the safety notes in the instruction sheet of the laser motion sensor S.

Experiment description

Modern distance meters use a periodically modulated laser beam for the measurement. They determine the phase shift between the emitted and the reflected modulated laser beam and, with the modulation frequency being known, obtain the time-of-flight t of the light on its path to and back from the reflector. Only afterwards do the distance meters calculate the distance with the aid of the known velocity of light.

In this experiment, the laser motion sensor S (laser S) is used as a time-of-flight meter because it is also capable of outputting the time-of-flight t directly. Water and acrylic glass of thickness d are held into the path of the beam, and then the resulting increase of the time-of-flight Δt is measured. With the velocity of light c in air measured in the previous experiment, the velocity of light c_M in matter can now be determined:

$c_M = 2d/(2d/c+\Delta t) = 1/(1/c+\Delta t/2d)$

Finally, the refractive index n is determined according to:

$n = c/c_M = c\cdot(1/c+\Delta t/2d) = 1 + c/2d\cdot\Delta t$

Equipment list

1	Sensor-CASSY	524 010 or 524 013
1	CASSY Lab 2	524 220
1	Laser motion sensor S	524 073
1	End buffer	from 337 116
1	Plate glass cell, 50 mm × 50 mm × 50 mm	477 03
1	Acrylic glass block	476 34
1	PC with Windows XP/Vista/7/8	

Experiment setup (see drawing)

Lay the laser S on the table with its broad side down, and connect it to the input A of the CASSY. Stick a piece of retroreflecting foil enclosed with the laser S to the end buffer, and put the end buffer on the ruler at a distance of approximately 50 cm from the laser so that the laser beam impinges perpendicularly on the center of the foil.

Before the measurement, allow the laser S to warm up for approximately 5 minutes in order that the zero shift becomes as small as possible.

Carrying out the experiment

- Load settings
- Hold the empty and dry plate glass cell into the path of the beam such that the visible reflections of the laser beam from the glass surface are not reflected back to the laser (rotate the cell by approximately 3°). Otherwise the laser also sees these reflections and will not be able to determine the time-of-flight correctly. The increase of the length of the path resulting from this rotation is smaller than 1 % and can thus be neglected.
- Define the zero of the time-of-flight (→ **0** ← in Settings ΔtA1).
- Record the first "measuring point" (air) with .
- Fill the plate glass cell with water.
- Record the second measuring point (water) with .
- Remove the plate glass cell.
- Define the zero of the time-of-flight (→ **0** ← in Settings ΔtA1) anew.
- Hold the acrylic glass block into the path of the beam such that the visible reflections of the laser beam from the glass surface are not reflected back to the laser (rotate the acrylic glass block by approximately 3°).
- Record the third measuring point (acrylic glass) with .

Evaluation

The two displays **Velocity of Light** and **Refractive Index** show the measuring results in the form of bar diagrams. The velocity of light in materials having a greater optical density decreases and the refractive index increases.

The literature values of the refractive indices of water and acrylic glass are n=1.33 and n=1.5.