

JAP04 - Angličtina pro fyziky 4

Refractive index

Petr Šafařík*
PřF MU

September 9, 2007

Contents

1	Theory	2
2	Methods of measuring refractive index	3
3	Summary	4
4	Thanks and questions	4

*mailto: petos@monoceros.muni.cz

Presentation

Introduction

Dear friends, colleagues,
let me express how nice it is to see you all here, at my presentation about: *Refractive index*. But before I begin, please, let me introduce myself and say some basic informations. My name is Petr Šafařík and I'm a student of astrophysics at Faculty of Science of Masaryc Univerzity. I've been interested for a long time to the refractive index and my bachelor work is about the same topic as-well. If you would not understand anything what I'm going to say, please, don't be shy and ask me.

I have divided my presentation into several parts:

The First part is about to end — it's the introduction.

The second part contains basical theory of refractive index.

The third part is about basic methods of measuring the refractive index.

I thing, that this is all I wanted to say to the first part.

1 Theory

Definition of the Refraction index : The refractive index of a medium is defined as the ratio of the phase velocity of a wave phenomenon such as light or sound in a reference medium to the velocity in the medium itself. It is most commonly used in the context of light with vacuum as a reference medium, although historically other reference media (e.g. air at a standardized pressure and temperature) have been common. It is usually given the symbol n . In the case of light, it equals

$$n = \sqrt{\varepsilon_r \cdot \mu_r}$$

where ε_r is the material's relative permittivity, and μ_r is its relative permeability.

For most transparent materials, μ_r is very close to 1 at optical frequencies, therefore n is approximately

$$n = \sqrt{\varepsilon_r}$$

Contrary to a widespread misconception, n may be less than 1. This has practical technical applications, such as effective mirrors for x-rays based on total internal reflection.

The phase velocity is defined as the rate at which the crests of the waveform propagate; that is, the rate at which the phase of the waveform is moving. The group velocity is the rate that the envelope of the waveform is propagating; that is, the rate of variation of the amplitude of the waveform. Provided the waveform is not distorted significantly during propagation, it is the group velocity that represents the rate that information (and energy) may be transmitted by the wave, for example the velocity at which a pulse of light travels down an optical fiber.

Now I turn to the problem of measuring the refractive index.

2 Methods of measuring refractive index

How can we measure the refractive index of air?

A value of the refractive index is now being achieved generally by two methods: the first of them (indirect) is based on modified Edlen's formula where atmospheric conditions as local pressure, temperature, humidity, and CO₂ concentration are measured by a set of atmospheric sensors collected at "weather bureau" unit.

The other method (direct) is based on a laser refractometer that monitors variability of the optical path length in the space surrounding the path of the laser beam. The traditional scheme of the refractometer is known very well. Mostly it is Michelson interferometer with a cell that is placed inside the measuring arm of the interferometer and that is being evacuated during measuring process. Because the resolution of the system is limited mainly by subdivision of the interference fringe (1 nm approximately), recent progress in the fundamental research leads to ultimate methods based on Fabry-Perot resonator and using optical frequency heterodyne mixing. The Fabry Perot cavity encloses a space with air to be investigated and a tunable laser is frequency locked to selected resonant mode of the cavity by a servo-loop. The optical frequency of the locked laser tracks immediately changes of the refractive index inside the cavity during the evacuation process.

For detection of the optical frequency changes of the locked laser, a heterodyne mixing with an etalon laser (optical frequency standard) is used. Then a record of the counted frequency determines directly the refractive index variations with the resolution in order better than 10^{-9} .

3 Summary

Let summarize it all. The refractive index of a medium is a measure for how much the speed of light (or other waves such as sound waves) is reduced inside the medium. For example, typical glass has a refractive index of 1.5, which means that light travels at 0.67 times the speed in air or vacuum. Two common properties of glass and other transparent materials are directly related to their refractive index. First, light rays change direction when they cross the interface from air to the material, an effect that is used in lenses and glasses. Second, light reflects partially from surfaces that have a refractive index different from that of their surroundings.

4 Thanks and questions

Well, thank you very much for your attention. However you could ask me during the hole time, if you have any questions, please, fell free to ask. If there are not any, I wish you nice rest of the afternoon and goodbye.