Optics, Reflection and Refraction

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Abstract: Optics is a branch of physics that studies light phenomena and the nature of light. Visible light is electromagnetic radiation that is perceived by the organ of vision - the eye. Optics studies phenomena related not only to the visible part of the radiation spectrum, but also to infrared and ultraviolet (ultraviolet) radiation.

Key words: Physics.light.visible.radiation

Introduction

Optics can be divided into two main areas according to the way optical phenomena are treated: geometric and physical optics. Geometric optics studies optical phenomena on the basis of basic laws that are empirical. It does not consider questions about the nature of light, unlike physical optics, which studies the nature of light and through this explains problems that are unsolvable in geometric optics.

Light as electromagnetic radiation

What can we say about what is light? For example, for Newton, light was a stream of particles, while for Huygens, light was similar to waves on water. Based on these theories, some simple optical laws such as the law of polarization can be explained. However, new electromagnetic results have favored the wave theory.

Light can be described as a swarm of particles called photons. Each photon carries a certain amount of energy. The entire range of radiation that occurs in space is called the light spectrum.

Types of electromagnetic radiation:

• gamma radiation

• X-rays

• ultraviolet radiation

• visible radiation (light)

• infrared radiation

• microwave radiation

• radio waves

Electromagnetic radiation differs from each other only in frequency. Light is produced when an electric charge moves in an electromagnetic field. An atom emits light when one of its electrons is excited by additional energy from a source. We describe the radiation of excited electrons as a wave.[1]

Solar radiation

The sun, as a light source, enables and sustains life on our planet with its radiation.

Optical radiation from the sun includes wavelengths from 100 to 10,000 nm. This wavelength range is divided into three areas:

100 – 400 nm Ultraviolet region

400 – 770 nm Visible region

770 – 10,000 nm Infrared region

The human eye registers a part of the spectrum between 400 and 700 nm. This part of the spectrum consists of six components of different colors: violet, blue, green, yellow, orange and red; arranged from shortest to longest wavelengths.

Ultraviolet radiation

The ultraviolet part of the spectrum is radiation of the shortest wavelengths, invisible to the human eye.

Based on the biological effect, ultraviolet radiation is divided into:

UV-C range from 180 to 290 nm

UV-B range from 290 to 320 nm

UV-A range from 320 to 400 nm

UV-C radiation is radiation in the shortest wavelengths of the UV spectrum. Radiation in this range is destructive to living organisms because it has enough energy to cause DNA damage in cells. However, UV-C radiation is almost completely absorbed in the atmosphere, so the amount of this radiation that reaches the Earth is negligible.

The largest amount of radiation that reaches the Earth's surface is radiation belonging to the UV-A range, because the ozone layer is almost completely transparent to radiation of these wavelengths.

UV-B radiation has an extremely harmful effect on all living things. Radiation of these wavelengths is largely absorbed in the atmosphere, even up to 90%.

UV protection

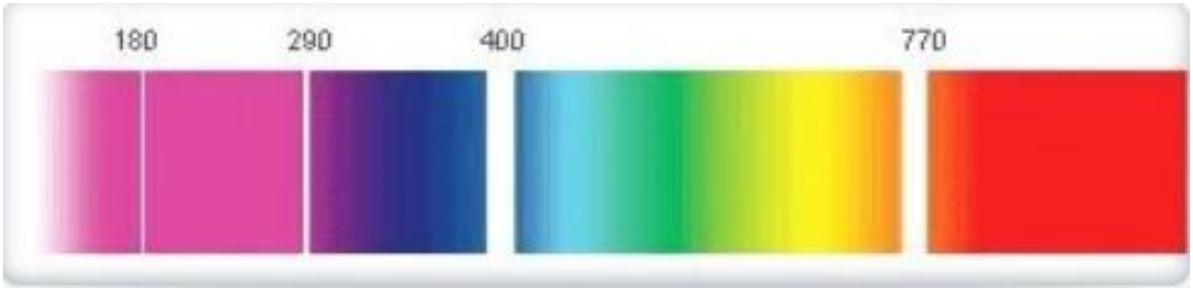
With the constant thinning of the ozone layer and the appearance of ozone holes, more and more harmful UV radiation reaches the earth's surface.

[1] https://studenti.rs/skripte/optika-refleksija-i-refrakcija/

Full UV filtration is especially important for tinted glasses (sunglasses, glasses with photo lenses and colored lenses). Behind tinted glasses, the pupil expands to a greater extent and in this way a very dangerous amount of harmful UV radiation can penetrate the eye. It is no less important that glasses with white lenses have the best possible UV radiation filtration. International standards require UV eye protection against wavelengths lower than 350nm, and tinted lenses are required to filter wavelengths below 400nm. Glasses and lenses with the original CE mark meet these international standards. Eye protection is especially important at higher altitudes and near water bodies.[2]

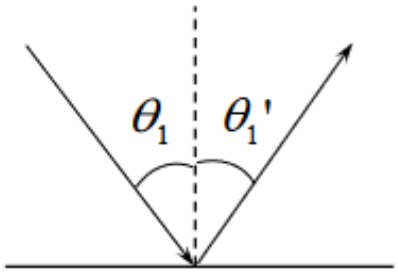
Interference

When two or more electromagnetic waves are superposed, they can be amplified at some points and attenuated at others.



Reflection of light

Reflection of waves occurs at the boundary between two media. A wave that reaches the boundary is reflected and propagates back. The angle of incidence is equal to the angle of reflection.[3]



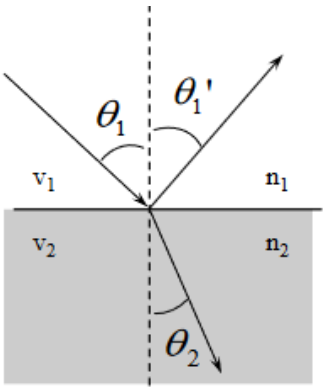
$$\theta_1 = \theta_1'$$

Refraction

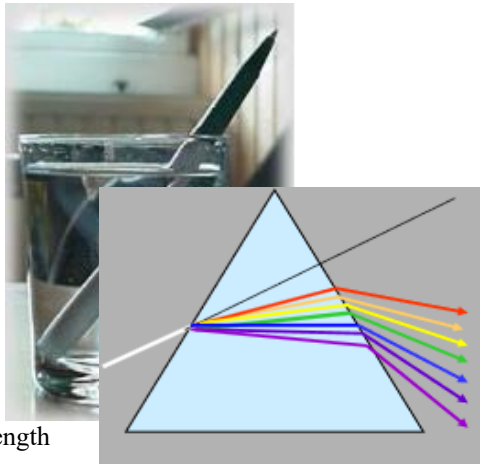
[2] https://www.optika7.rs/enciklopedija/uv-zracenje
[3] http://mapmf.pmfst.unist.hr/~agicz/PredNU10slike.pdf

Wave refraction occurs when waves continue to propagate from one medium into another, and when the wave speeds are different in different media.

Law of refraction



$$\frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$$



The value of the refractive index in a medium depends on the wavelength of the light. This phenomenon is called dispersion. Snell's law shows that light of different wavelengths will be refracted at different angles when it strikes a medium:

- Prism
- Rainbow
- Dispersion and prism DISPERSION OF LIGHT

Modern branches of optics

Photometry deals with the measurement of the properties of light.

Atmospheric optics investigates the phenomena caused by the refraction, reflection, polarization, scattering, and diffraction of light in the Earth's atmosphere.

Optoelectronics studies and applies devices that emit, modulate, transmit, or detect light or other electromagnetic radiation.

Quantum optics describes optical processes using the methods of quantum mechanics, investigating quantum and relativistic phenomena associated with light, in particular the dual (wave and particle) nature of light and the interaction of light with matter. If light is represented as a beam of particles, these particles are light quanta or photons, each of which has energy: E = hν, which depends on the frequency ν of the electromagnetic wave, and momentum: p = E/c, where h is Planck's constant.

A consequence of the particle nature of light is radiation pressure, which in the case of high-intensity pulsed laser beams takes on significant values, and is therefore used to change the structure of matter at the atomic level (e.g., cooling atoms).[4]

Nonlinear optics studies optical phenomena in optical media with a nonlinear relationship between the electric field strength vectors and the electric polarization. It deals with highly coherent laser light sources that produce focused light beams of high power, which cause nonlinear effects. Ordinary light changes its path but not its frequency as it travels through an optical medium, while nonlinearities in the interaction of light with matter can also cause a change in frequency: a nonlinear optical phenomenon occurs when a matter emits light of a higher frequency than the frequency of the light that is incident on it.

[4] optika. *Hrvatska enciklopedija*, *mrežno izdanje.* Leksikografski zavod Miroslav Krleža, 2013. – 2025. <https://enciklopedija.hr/clanak/optika>.

Non-imaging optics studies light in transmission. It focuses on preventing light beam dispersion and energy losses during transmission, so, for example, it investigates what shapes of optical fibers lead to chaotic reflections and power losses in transmission, or what devices give better results when using solar energy.

Izvori

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