Engineering Optics

Lecture 25

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by

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O-ray and E-ray

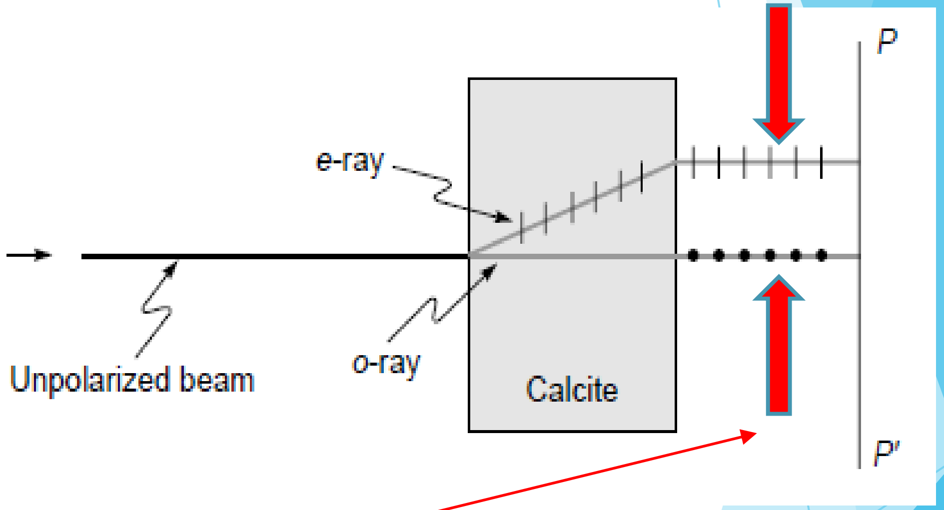
1. Both ordinary and extraordinary waves are linearly polarized.
2. $\mathbf{D} \cdot \mathbf{k} = 0$ for both *o*- and *e*-waves **(42)**

   Thus **D** is always at right angles to **k**, and for this reason the direction of **D** is chosen as the direction of "vibrations."
3. If we assume the z axis to be parallel to the optic axis then

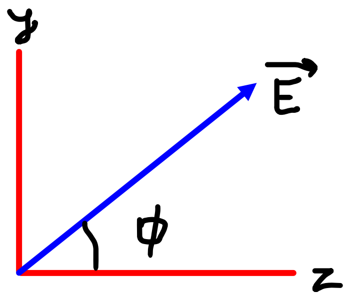
   $$\mathbf{D} \cdot \hat{\mathbf{z}} = 0 \qquad (\text{and } \mathbf{D} \cdot \mathbf{k} = 0) \qquad \text{for the } o\text{-wave} \quad \mathbf{(43)}$$

   Thus for the *o*-wave, the **D** vector is at right angles to the optic axis as well as to **k**.
4. On the other hand, for the *e*-wave, **D** lies in the plane containing **k** and the optic axis, and of course,

   $$\mathbf{D} \cdot \mathbf{k} = 0 \qquad \mathbf{(44)}$$



$$E_y = E_0 \sin\phi \cos(kx - \omega t)$$
$$E_z = E_0 \cos\phi \cos(kx - \omega t)$$



where k ($= \omega/c$) represents the free space wave number. Thus, at $x = 0$, we have

$$E_y(x = 0) = E_0 \sin\phi \cos\omega t$$
$$E_z(x = 0) = E_0 \cos\phi \cos\omega t$$

Inside the crystal, the two components will be given by

$$E_y = E_0 \sin\phi \cos(n_o kx - \omega t) \qquad \text{ordinary wave}$$
$$E_z = E_0 \cos\phi \cos(n_e kx - \omega t) \qquad \text{extraordinary wave}$$

If the thickness of the crystal is d, then at the emerging surface, we have

$$E_y = E_0 \sin\phi \cos(\omega t - \theta_o)$$
$$E_z = E_0 \cos\phi \cos(\omega t - \theta_e)$$

where $\theta_o = n_o kd$ and $\theta_e = n_e kd$. By appropriately choosing the instant $t = 0$, the components may be rewritten as

$$\boxed{\begin{aligned} E_y &= E_0 \sin\phi \cos(\omega t - \theta) \\ E_z &= E_0 \cos\phi \cos\omega t \end{aligned}}$$

where

$$\theta = \theta_o - \theta_e = kd\,(n_o - n_e) = \frac{\omega}{c}(n_o - n_e)d$$

1. -ve crystal : θ is +ve
2. +ve crystal: θ is -ve

Now, if the thickness d of the crystal is such that $\theta = \pi/2$, the crystal is said to be a quarter wave plate (usually abbreviated as QWP)—a phase difference of $\pi/2$ implies a path difference of a quarter of a wavelength. On the other hand, if the thickness of the crystal is such that $\theta = \pi$, the crystal is said to be a half wave plate (usually abbreviated as HWP).

Module 2

LASER Basics

Laser operation, Absorption, Spontaneous Emission and Stimulated Emission, Population & Inversion, Three- and Four Level Laser Systems, Laser Characteristics- Types of Lasers: Solid-State Lasers, Gas Lasers, Semiconductor Lasers.

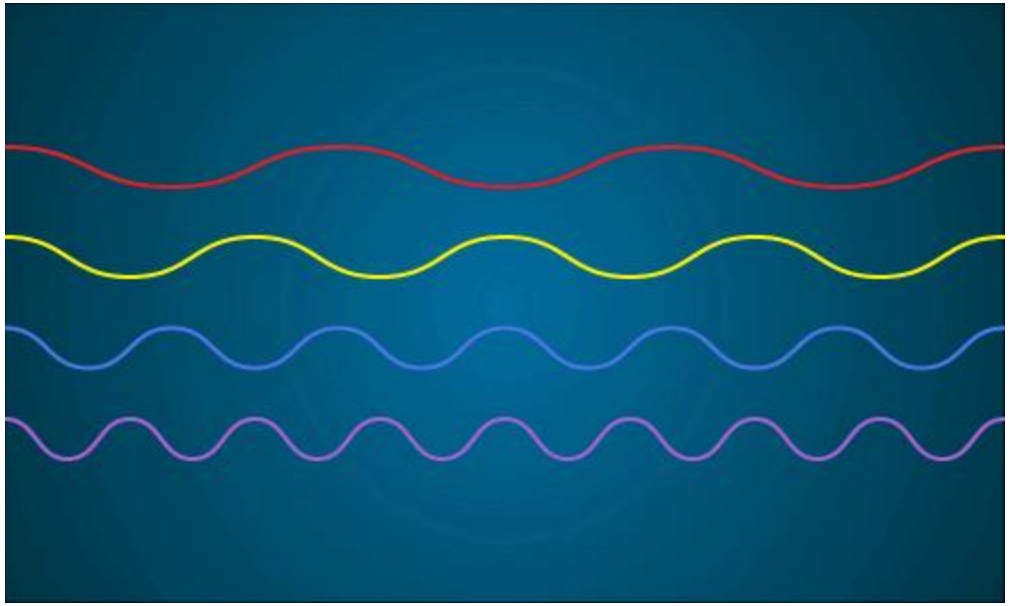
L A S E R

Light Amplification by Stimulated Emission of Radiation

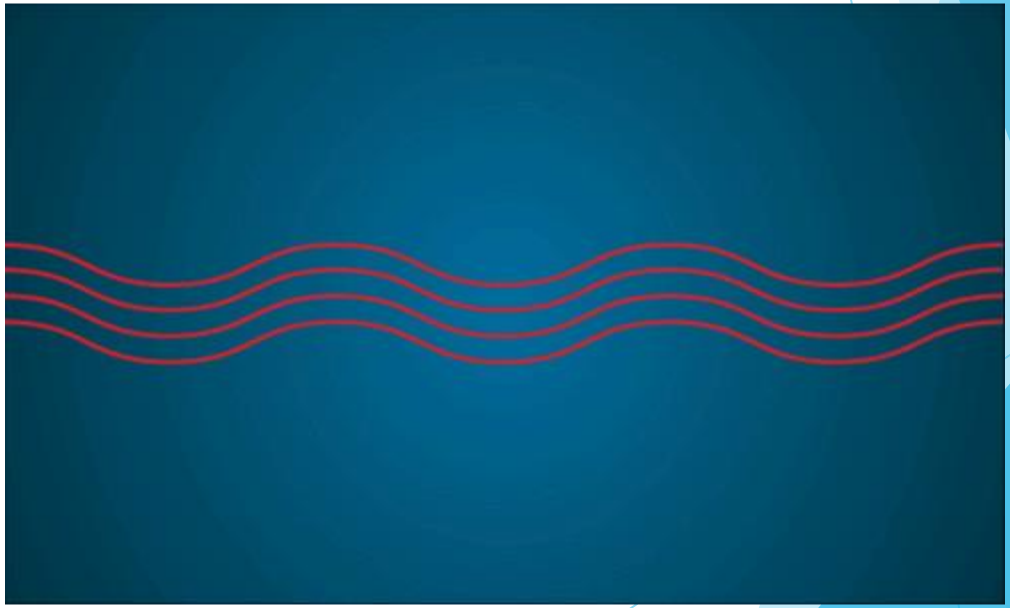
LASER is different!

LASER: Lasers produce a very narrow beam of light

Sunlight or a lightbulb—is made up of light with many different wavelengths. Each color of light has a different wavelength. $\lambda_V < \lambda_R$ Our eyes see this mixture of wavelengths as white light.



This Fig. shows a representation of the different wavelengths present in sunlight. When all of the different wavelengths (colors) come together, you get white light. Image credit: NASA

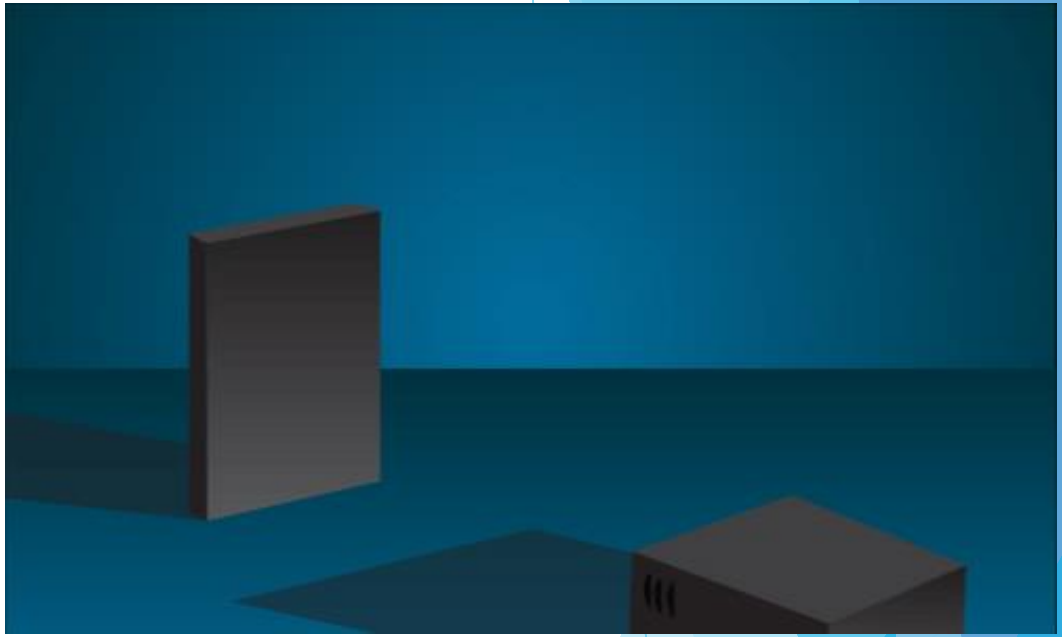


This Fig. is a representation of in phase laser light waves. Image credit: NASA

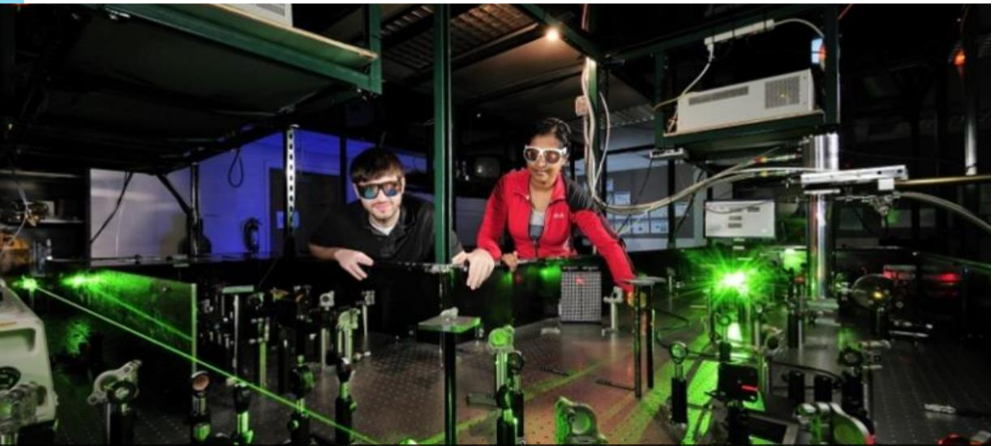
LASER light

Properties:

- **Directionality:** highly directional, divergence < 10^{-5} rad
- **High power:** Continuous wave lasers having power levels of ~10^5 W and pulsed lasers having a total energy of ~50,000 J
- **Tight focusing:** as highly directional, laser can be focused to areas of approximately few micrometers squared
- **Spectral purity:** Laser beams can have an extremely small spectral width $\Delta\lambda$ ~ 10^{-6} Å



This animation shows how a laser can focus all of its light into one small point. Credit: NASA



https://ultrafast.ku.edu/

** It is quite safe to look at a 500 W bulb, it is very dangerous to look directly into a 5 mW laser beam → damage retina*

https://scitechdaily.com/images/Bright-Sunlight.jpg

https://www.homestratosphere.com/types-of-flashlights/

Applications

Because of such unique properties of the laser beam, it finds important applications in many diverse areas

- can cut through diamonds or thick metal
- delicate surgeries → eye surgeries
- recording and retrieving information
- surveying, remote sensing
- communications and in carrying TV and internet signals (Laser pulses having very small cross-sectional area (and high energy) can be guided through special fibers
- laser printers, bar code scanners
- They also help to make parts for computers and other electronics.

Thank You