DeAnza College

Optics
Polarization
Birefringence

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De Anza College

June 21, 2018

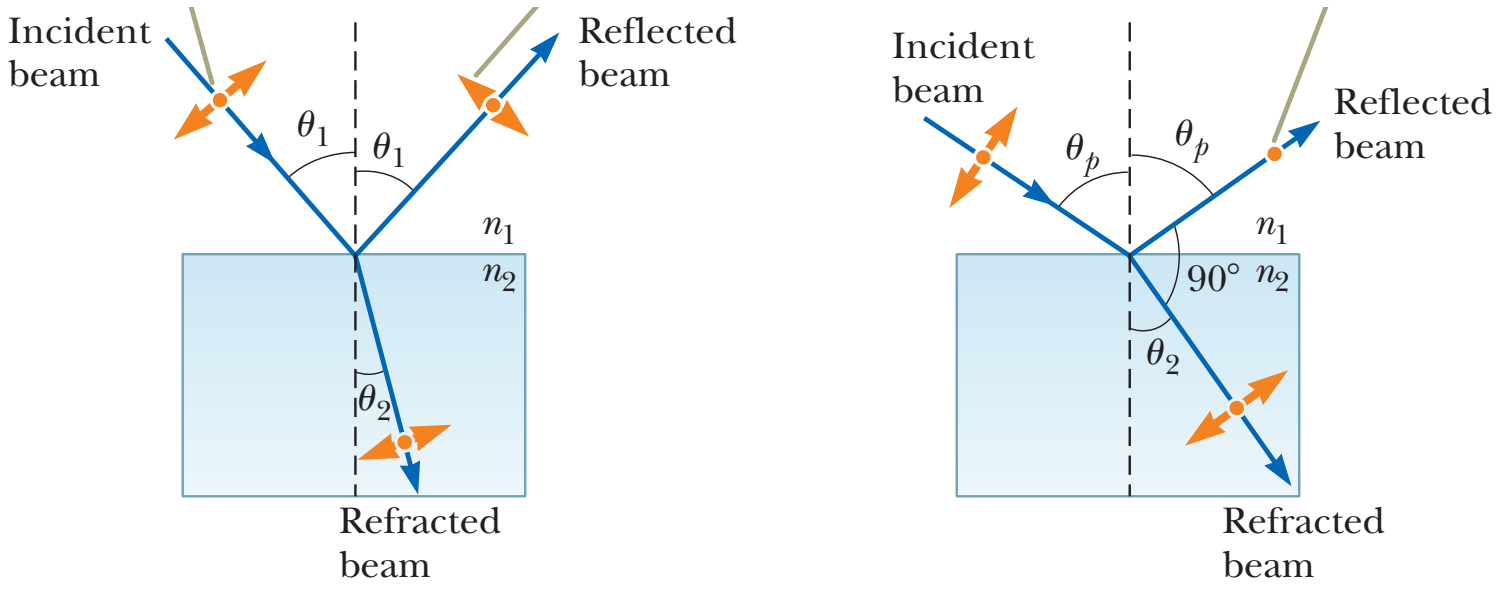
Last time

- the interferometer and gravitational waves
- polarization
- Brewster angle

Overview

- polarization
- birefringence
- Rayleigh scattering

Creating Polarized Light: by Reflection

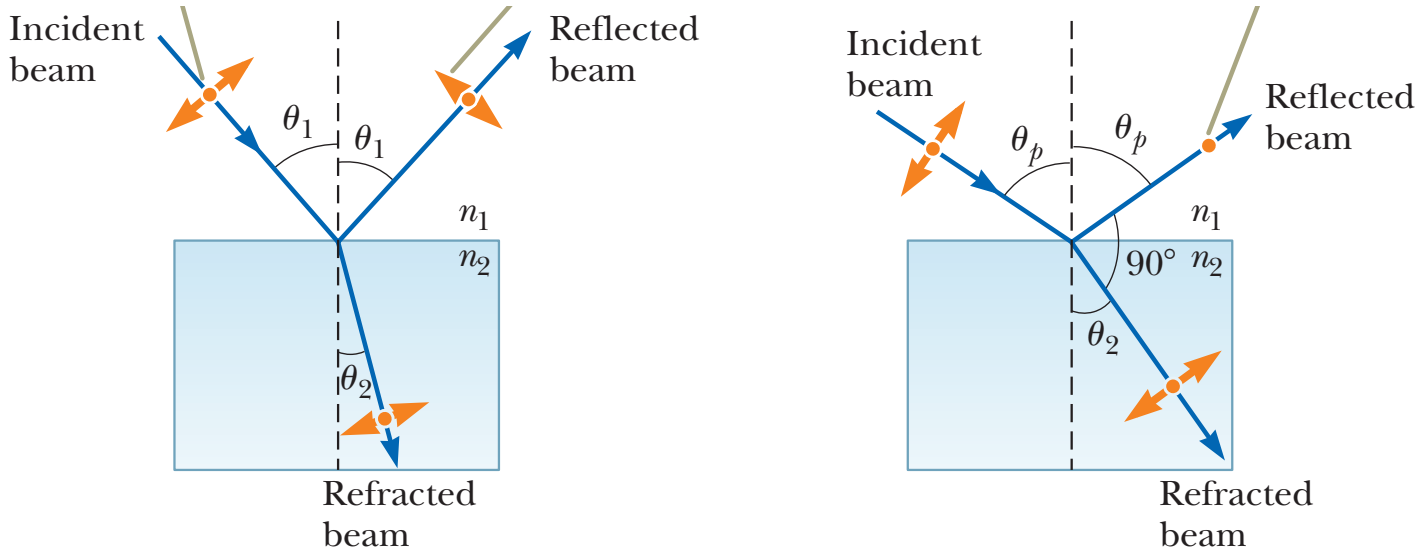


The dipoles in the surface cannot create a ray that has an E-field oscillating in the direction that the ray travels.

When the reflected and refracted rays are perpendicular, the reflected ray is completely polarized parallel to the surface.

Creating Polarized Light: by Reflection

The value of the incident angle for the reflected and transmitted rays to be perpendicular, θ_p is called **Brewster's angle**.



Notice, $\theta_2 = 90° - \theta_p$. From Snell's Law:

$$\begin{aligned} n_1 \sin\theta_p &= n_2 \sin(90° - \theta_p) \\ n_1 \sin\theta_p &= n_2 \cos(\theta_p) \end{aligned}$$

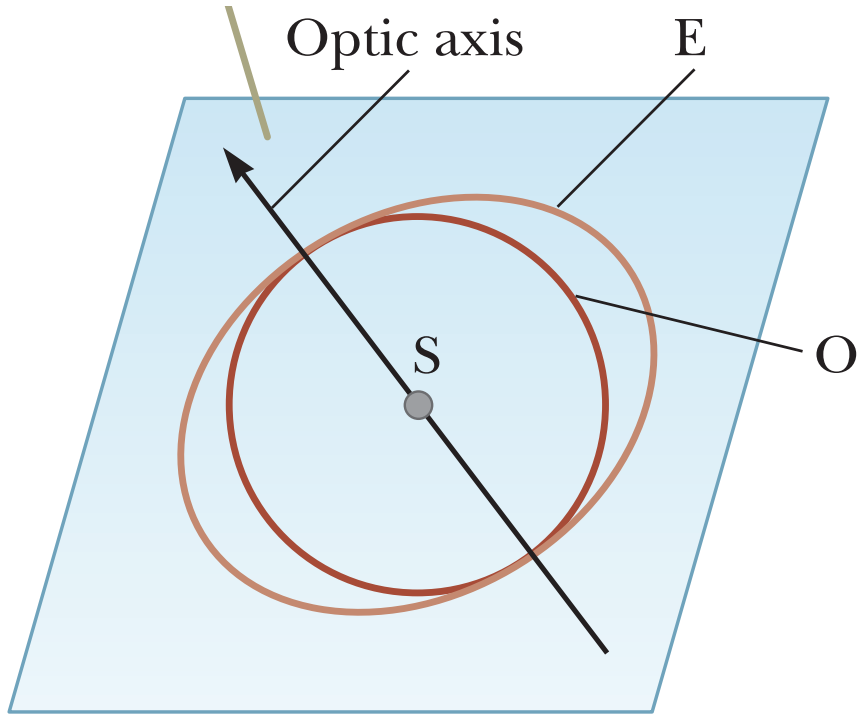
So,

$$\theta_p = \tan^{-1}\left(\frac{n_2}{n_1}\right)$$

Creating Polarized Light: Birefringent Materials

Calcite and quartz are examples of crystals that have a special property: the speed of light (phase velocity) is not the same in all directions.

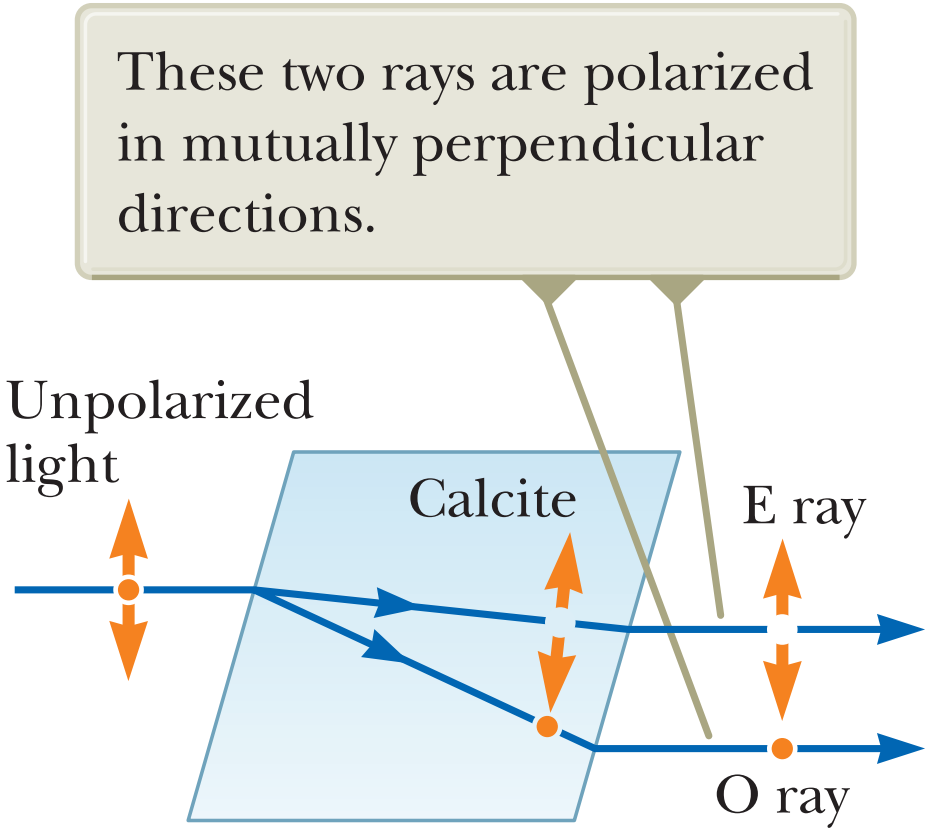
The speed of a ray depends on both the the direction it travels and the direction of polarization.



S is a point source emitting in all directions: the wavefronts don't remain spherical for one type of polarization (E-ray).

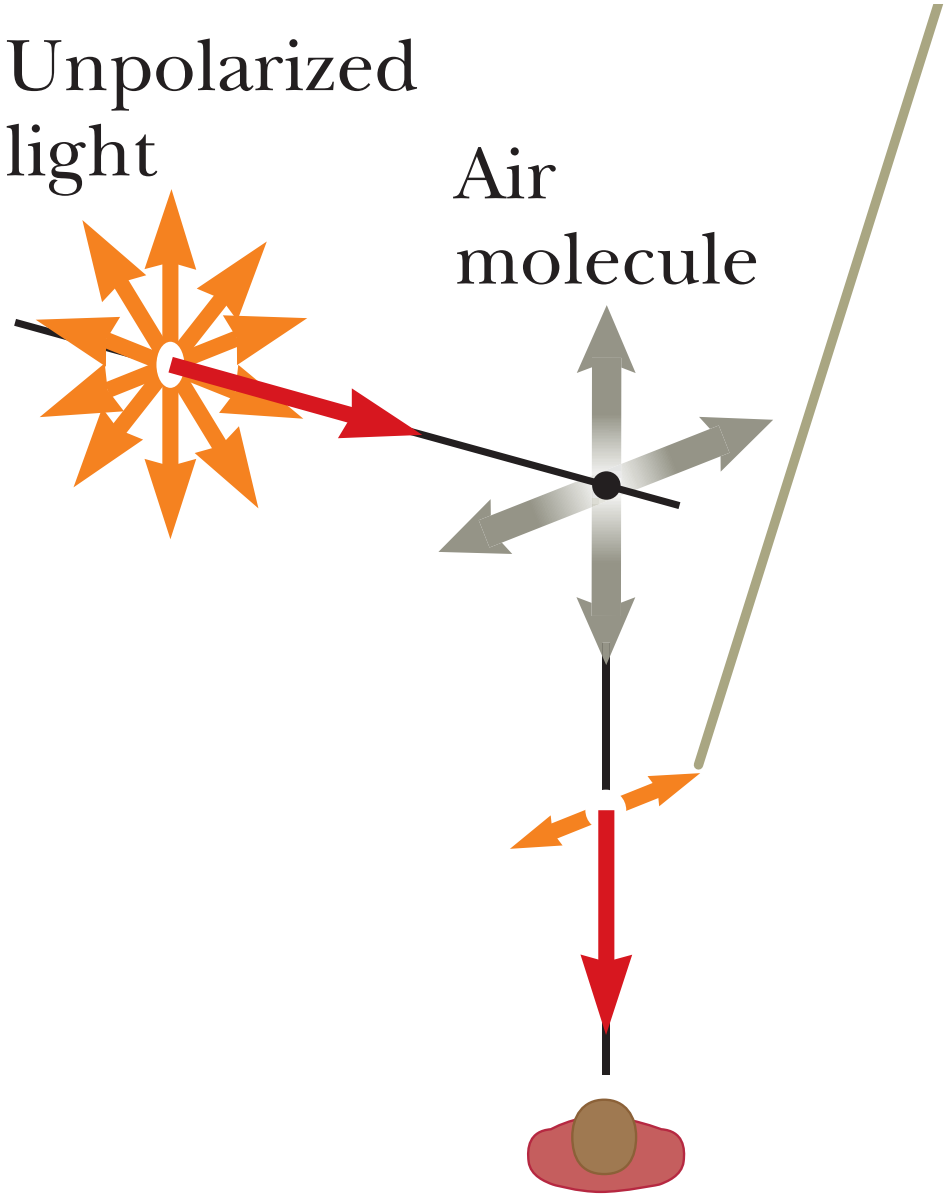
Creating Polarized Light: Birefringent Materials

There are two refracted rays in a birefringent material:



The ordinary ray (O) and the extraordinary ray (E). Both have different polarizations.

Creating Polarized Light: Scattering



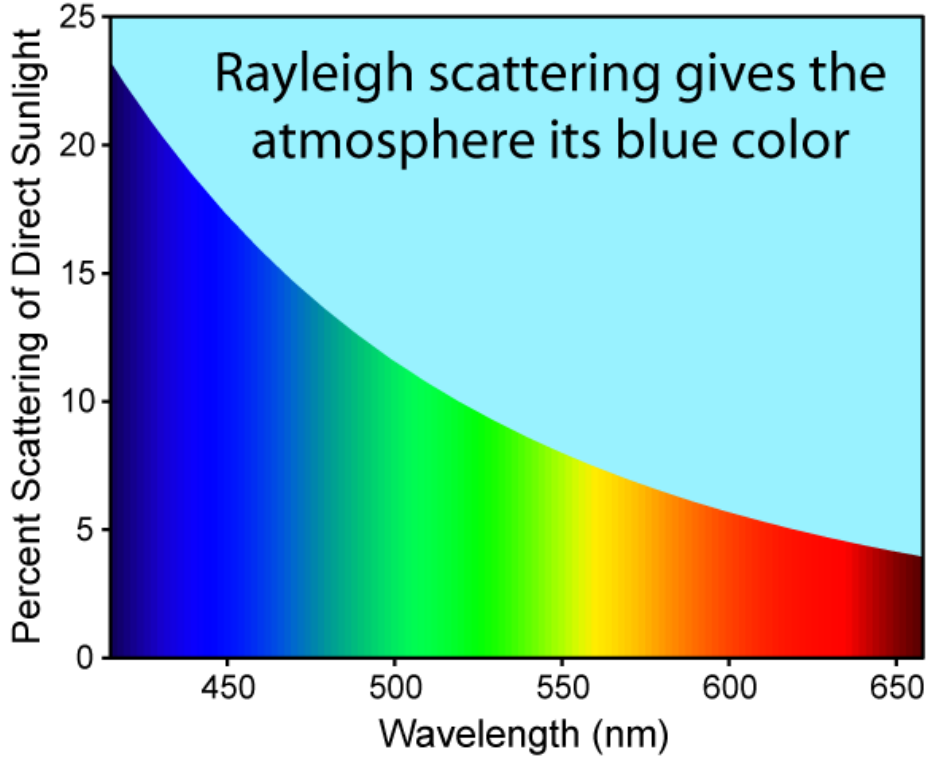
Scattering depends on Wavelength

When light is scattered by particles much smaller than the wavelength of the radiation (Rayleigh scattering), the intensity of the scattered light goes as:

$$I = I_0 \frac{(\text{const.})}{\lambda^4}(1 + \cos^2\theta)$$

(θ is the scattering angle.)

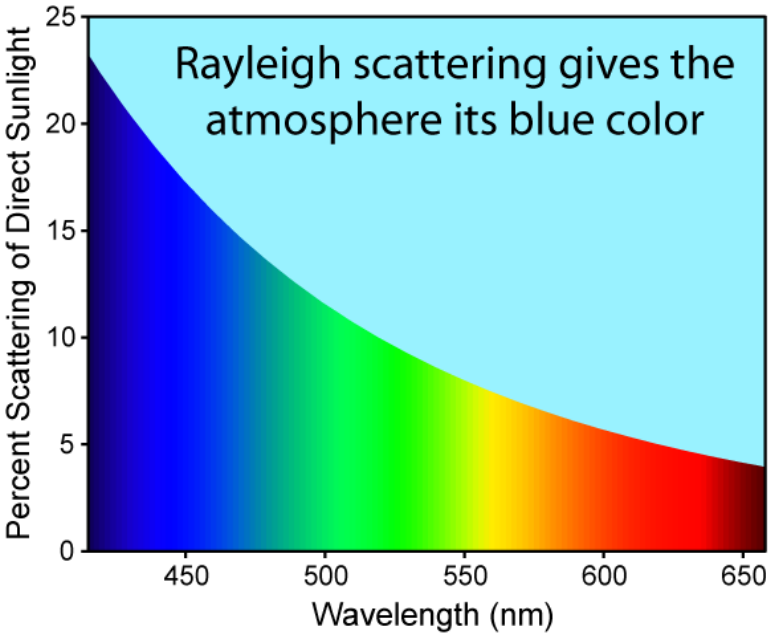
Shorter wavelengths (violet) are scattered more intensely.



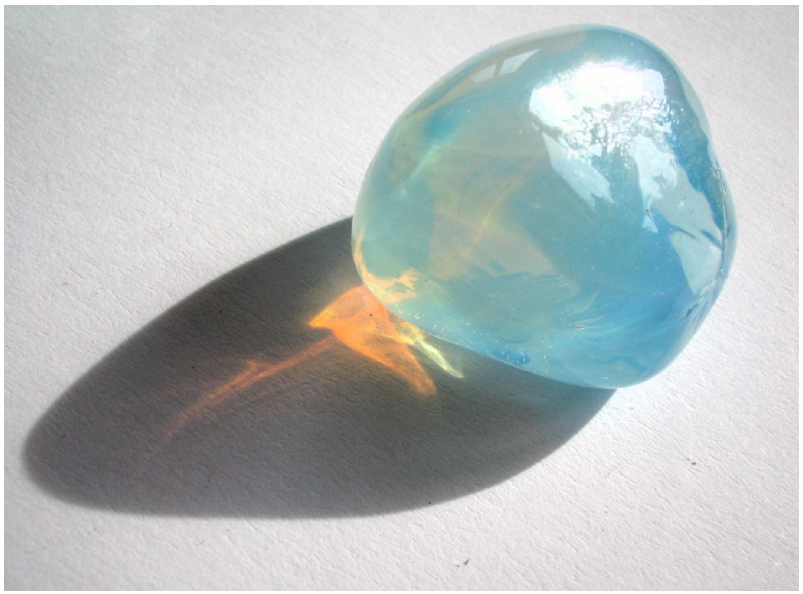
Why the Sky is Blue: Rayleigh Scattering

The amount (intensity) of the light scattered by small particles depends on the wavelength:

$$I \propto \frac{1}{\lambda^4}$$



shorter wavelength light is scattered more



opalescent glass

[1]Left, Robert A. Rohde, Wikipedia; right, user optick, https://www.flickr.com/photos/optick/112909824/

This Course

Questions we wanted to answer:

- How does an airplane wing create an upward lifting force?
- Why does hot metal start to glow read when heated?
- When a block of ice is left out at room temperature and pressure it will melt. Why does this happen?
- Why is it not uncommon to see a glass cup fall and shatter, but we never see a pile of broken glass reassemble itself into a cup?
- Why can you hear someone's voice when they are still around a corner from you, but you can't see them?
- Why is the sky bright during the day? Why is the daytime sky blue?

Summary

- polarization
- birefringence
- scattering

Final Exam 9:15-11:15am, Tuesday, June 26.

Homework Serway & Jewett:

- prev: Ch 38, onward from page 1182. OQs: 1, 7; Probs: 45, 49, 51, 63, 65, 70
- new: Ch 38, onward from page 1182. Prob: 75